Evaluation of *SiteManager* as a Tool for Collecting Performance Time Data

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Evaluation of *SiteManager* as a Tool for

Collecting Performance Data

by

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(ABSTRACT)

This work evaluates *SiteManager*, the construction documentation system used by VDOT, as a tool for collecting the daily installed quantity and active crew days necessary to populate the operations level of the database. This evaluation first sought to determine if *SiteManager* was a feasible option for collecting performance data. This was done by establishing data collection methods to enable *SiteManager* to have the ability to collect performance data, implementing the methods on select projects, resolving issues, and developing recommendations to cause *SiteManager* to be a more practical option. Secondly, a statistical analysis was performed to determine if the data collected from *SiteManager* was reasonably accurate. Thirdly, the technical issues of transferring performance data from *SiteManager* into the performance time database were resolved. It was found *SiteManager* could not be used in its current format to collect performance data and some modifications are required.

Dedication

For Lindsay, Isaac, and James.

You bring so much joy to life. I love you.

Acknowledgements

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Chapter 1: Introduction

1.1. Background

When developing a construction schedule, there are two elements one must consider, logic and duration. Logic is the sequence of construction activities and reflects the planned order of the work. Duration is the time required to complete each construction activity in the plan of work. Knowledge and experience are generally used to develop the logic of a schedule. These are also used when determining the duration for activities in a schedule, but performance data can be a great tool for assisting a scheduling engineer when determining the duration of an activity.

Developing schedules are critical to determining contract time. Schedules show the performance time for controlling items of work based on historical performance data. When these controlling items are arranged in a logical sequence, the schedule will present an estimate of contract time.

In 1991, the Federal Highway Administration (FHWA) required states through 23CFR 635.121 to have an approved procedure for determining contract time. Since that time, many states have complied with these procedures. The Virginia Department of Transportation (VDOT), however, does not currently have approved procedures to set contract time, and it is necessary that the VDOT develop such procedures.

The FHWA has published suggestions for complying with this requirement in technical advisory 5080.15 (FHWA 2002). This suggests that state transportation

agencies should maintain a database of average production rates based on historical project data to assist engineers in determining contract time.

The development of such a database is one objective of the VDOT – Virginia Tech Partnership for Project Scheduling (Partnership). This database will be used to maintain bid item level performance data for different operations of construction projects. This database is called Bid Item Duration Database System (BIDDS). The performance data will then be used to assist VDOT scheduling engineers in estimating activity durations and setting contract time. Figure 1.1 illustrates this process and emphasizes the focus of this research, to evaluate *SiteManager* as a tool for VDOT to use to collect the data necessary to populate BIDDS.
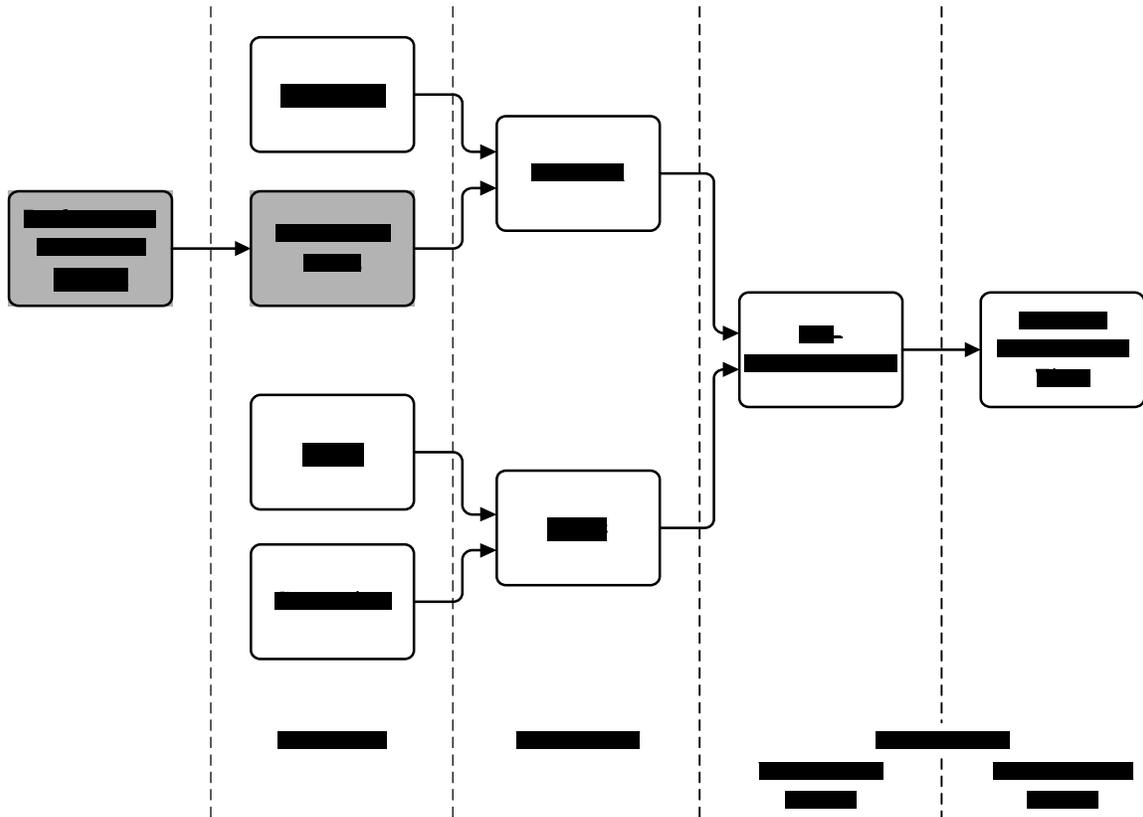
Figure 1.1: Contract Time Estimating Process (Williams 2006)

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SiteManager is the construction documentation system which the VDOT is currently using on their construction projects and has been selected as a tool to use to collect performance data. VDOT field personnel use this system on a daily basis to track construction operations and maintain records used to pay the contractor. By using *SiteManager*, performance data can be collected without a need for the creation of an additional data collection tool.

1.2. Objectives

The objective of this research was to evaluate *SiteManager* as a performance data collection tool. This objective will be achieved by answering the following four research questions:

1. Can *SiteManager* be used in its current format to gather the performance data required to populate BIDDS?
2. Does the data from *SiteManager* agree with performance data manually recorded by project personnel?
3. What modifications, if any, to the *SiteManager* system are required to provide the performance data necessary to populate BIDDS?
4. What modifications, if any, to the methods by which *SiteManager* is used are required to provide the performance data necessary to populate BIDDS?

This was done by assessing both *SiteManager* and the performance data it collected to ensure it met three criteria:

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1. *SiteManager* must be feasible to collect the required data

2. The data must be reasonably accurate

3. The data must meet the technical requirements for import into BIDDS.

All data collected was used to help evaluate the data collection process and perform a statistical analysis.

1.3. Scope and Limitations

The scope of this research was to evaluate *SiteManager* as a tool for collecting the performance data required by BIDDS. This was done by first determining data collection procedures to implement on selected VDOT projects. After implementing these procedures, *SiteManager* will be observed to ensure it is a feasible option. Solutions will be found to data collection issues by either resolving the issue or forming a recommendation to resolve the issue. The data collected from these VDOT projects will be used to perform a statistical analysis. This will be done to ensure the data obtained through the use of *SiteManager* is reasonably accurate. Using the technical requirements of BIDDS, a process of transferring data from *SiteManager* to BIDDS will be developed. Recommendations will be solidified from the conclusions of this research for the Partnership to deliver to VDOT.

This research was limited by the following areas:

1) The data gathering tool evaluated was *SiteManager* and it was evaluated in its use to collect DIQ and ACD data.

2) The activities used by this research were defined by the VDOT – VT Partnership and the form and format of the data must meet the form and format of BIDDS. Only data for BIDDS was collected.

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3) Only 6 highway and bridge construction projects from within the VDOT Salem and Staunton Districts were chosen. These districts were chosen because of their proximity. The projects selected were those containing substantial work to be completed during the winter months. This was because the collection of data was during the winter months.

1.4. Organization of Thesis

This thesis was divided into five major divisions, understanding the challenge, developing the methodology, implementing the methodology, analysis of results, and review. The document map showing the organization of the chapters in the five major divisions is presented as Figure 1.2.

Chapter 2:   Literature Review – literature related to this thesis is examined and discussed. This chapter discusses performance data, performance data research of state transportation agencies, contemporaneous data collection procedures, and the uses and capabilities *SiteManager*.

Chapter 3:   Preliminary Evaluation of *SiteManager* – the initial evaluation performed to determine if *SiteManager* could be used to collect the performance data. This chapter also identifies some alternative data collection procedures which were created to ensure *SiteManager* could be used to collect data.

Chapter 4:   Design of Field Study – this chapter is composed of how the field study was designed and the procedures followed to select projects for data collection.

Chapter 5:   Conduct the Field Study - discusses how the designed field study was conducted.

Chapter 6:   Feasibility Analysis of *SiteManager* - addresses the practical use of *SiteManager* as a tool for collecting the performance data as well as steps taken to solve potential data collection issues.

Chapter 7:   Accuracy Analysis of Performance data - describes the statistical analysis which was performed to evaluate the accuracy of data collected using *SiteManager*.

Chapter 8:   Technical Analysis of Performance data – this chapter is involved in insuring the data collected during the field study could be transformed into the form and format required for exporting into BIDDS.

Chapter 9:   Final Evaluation – summary of the results from the technical, accuracy, and feasibility analysis.

Chapter 10:   Recommendations – the suggestions provided to VDOT relating to the use of *SiteManager* as a tool for collecting performance data.

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Understanding the Challenge	Chapter 1 Introduction	Chapter 2 Literature Review
Developing the Methodology	Chapter 3 Preliminary Evaluation of *SiteManager*	Chapter 4 Design of Field Study
Implementing the Methodology	Chapter 5 Conduct the Field Study	
Analysis of Results	Chapter 6 Feasibility Analysis of *SiteManager*	Chapter 7 Accuracy Analysis of Performance Data
	Chapter 8 Technical Analysis of Performance Data	
Review	Chapter 9 Final Evaluation	Chapter 10 Recommendations

Figure 1.2: Document Map

Chapter 2: Literature Review

2.1. Introduction

This research pertains to evaluating the use of a construction documentation system in collecting performance data. Therefore, it was imperative an understanding of performance data is attained, including what data is required to enable scheduling engineers to determine the performance time of an activity. For this reason production rates were examined. In addition, the research studied the methods by which other state transportation agencies obtained performance data and developed production rates. The issue of whether data should be collected retrospectively or contemporaneously, was investigated. In order to evaluate *SiteManager*, training was experienced and user manuals were studied to learn how to use the *SiteManager* software and what its capabilities were. In order to statistically analyze the data obtained from the various methods of data collection, research on methods of statistical analysis were studied.

2.2. Performance Data

A project is normally divided into activities for planning purposes. An activity is a work step that has a definite beginning and ending, and time is required to accomplish the activity (Clough 2000). An activity may include a quantity of work which must be performed to complete the activity. A production rate can be used to determine the time required to complete the activity (Peurifoy 2002).

Production rates are commonly used by estimators to prepare accurate cost estimates. An estimator will use a production rate to determine the time required to complete an activity. Production rates can also be used as the basis to measure the effectiveness of the progress of an activity and quantify the inputs impeding the progress of work (Hachey 1995).

A production rate is the rate work is performed by a person, crew, or piece of equipment. It is usually defined as a unit of work per unit of time. Consequently, two elements are required to develop a production rate, quantity of work and time (Peurifoy 2002).

2.2.1 Quantity of Work

According to Thomas (2000), there are different ways to measure the quantity of work produced. The process one uses to measure the different quantities of work produced depends greatly on the nature of the work and the construction methods used to complete the work. The different ways to measure the quantity of work produced is as follows:

1. Units Completed – This involves physical measurement of a quantity of material placed. Examples are cubic yards of concrete or number of ceiling tiles placed. This is best suited for situations when the work items can easily be measured or counted.

2. Percent Complete

   a. Subjective Measurement - An estimate of the amount of work completed on an activity is made by a supervisor or project inspector.

b. Level of Effort – This method is similar to percent complete; however, it relies on predetermined rules to give credit for partially completed work that must evolve through several subtasks. Each subtask is assigned a portion of the percentage of the total activity. As work is being performed on multiple different subtasks, their individual percentage complete can be used to calculate the percentage complete for the activity.

c. Incremental Milestones - A predetermined percent complete is associated with each milestone.

d. Start/Finish Percentages - Percent complete is arbitrarily assigned to the start of a task (such as 20% or 30%) and when the activity ends, it is credited for being 100% complete. No intermediate percentages are used.

The most common method used in the construction industry to measure the quantity of work produced is in terms of units completed (cubic yards, linear feet, each, etc.). This is especially used in the construction industry to compensate for different scales and types of work produced. When work is measured in terms of percentage complete, one cannot account for the different scales of work. The percentage of time required to complete an activity would by the same no matter of its scale. For this reason, measuring work produced in terms of units completed yield more accurate results (Thomas 2000).

There are various levels of detail which can be used when making measurements using units of work completed. For example, the footers on a bridge can be measured by number of footers or by cubic yards. In this example, measuring quantity of work produced in terms of number of footers is less detailed than measuring quantity of work produced in terms of cubic yards. It does, however, provide greater ease when measuring the quantity of work produced (O'Conner 2005). It is more common to use more detail when measuring the quantity of work produced because this provides more accuracy when developing a production rate (Thomas 2000).

2.2.2 Time

There are various levels of detail by which time can be measured. The measurement can be as detailed as using units of hours or units of months. The most common unit of time measurement is in terms of days or hours (Schuette 1994). Even when measuring time with units of days, there are various levels of detail to which a day can be divided to attempt to increase the accuracy of the measurement. This is the case because a day is usually based on an 8 hour work day. If the contractor works more or less than 8 hours in a day, the day can be divided into fractions of a day to attempt to increase the accuracy of the measurement. Research has shown, dividing a day into fractions of a day can increase the accuracy (Leslie 2000). However, little accuracy or precision is gained and the amount of effort required to divide a day into fractions of a day may not be worth the extra accuracy obtained.

2.3. State Transportation Agency Performance Data Research

Various state transportation agencies have sponsored research to either develop production rates or improve existing production rates and contract time determination methods. The research sponsored by the Louisiana DOT, Texas DOT, and Florida DOT as well as a study performed on the Memorial Bridge is examined and the significant concepts of are discussed.

2.3.1 Louisiana DOT

Leslie (2000) developed production rates for rural asphaltic concrete overlay projects for the Louisiana DOT by choosing 36 projects to analyze historical project documents and collect time and quantity data. He presents four methods for generating contract time and performed a statistical analysis to determine which method produced the most accuracy. Each method was different because of the amount of detail assigned to time to develop production rates. The four methods used area as follows:

Method 1.   Assigns a full day of work to each daily quantity recorded. The result of this method is the average of the daily quantities. *Time = 1 day*

Method 2.   Compares the daily quantity with the mean daily quantity established in Method 1. The assignment of the time-values are described as follows:

- If the Daily Quantity ≤ Mean; *Time =* $\dfrac{DailyQuantity}{Mean}$ *day*

- If the Daily Quantity > Mean; *Time = 1.0 day*

Method 3.   Compares the daily quantity with the mean daily quantity established in Method 1. The assignment of the time-values are described as follows:

- If the Daily Quantity ≤ Mean; *Time = 0.5 day*

- If the Daily Quantity > Mean; *Time = 1.0 day*

Method 4. Assumes that an eight-hour day has a time-value of one day. Therefore, the maximum time-value that can be awarded per day is equal to three days (24 hours per day/8 hours per time-value). The computations for this method used blocks of time in increments of 0.5 time-values.

- If the Daily Quantity $\leq$ (0.5 x Mean); *Time =* $\dfrac{DailyQuantity}{Mean}$ *day*

- If (0.5 x Mean) < Daily Quantity $\leq$ (1.5 x Mean); *Time = 1.0 day*

- If (1.5 x Mean) < Daily Quantity $\leq$ (2.0 x Mean); *Time = 1.5 days*

- If (2.0 x Mean) < Daily Quantity $\leq$ (2.5 x Mean); *Time = 2.0 days*

- If (2.5 x Mean) < Daily Quantity $\leq$ (3.0 x Mean); *Time = 3.0 days*

- If Daily Quantity > (3.0 x Mean); *Time = 3.0 days*

Leslie used these four methods to produce two estimates of contract time for each of the 36 projects used when developing the production rates. The first, estimated contract time by assuming concurrent activities and the second estimated contract time by assuming no concurrent activities. These estimated contract times were then compared with the actual contract time to determine which method produced the most accurate time estimate. He determined method 4 produced the most accurate contract time estimate when no concurrent activities were considered and method 1 produced the most accurate contract time when concurrent activities were considered. He then compared these two methods to determine which of the two produced the most accurate time estimate. He determined method 4 considering no concurrent activities produced the most accuracy; however, little precision and accuracy was lost when method 1 was used. Because of the

ease of computing the production rates, method 1 was determined to be the overall best method.

2.3.2 Texas DOT

O'Connor, et al. (2004) worked on improving the production rates used in the TxDOT Contract Time Determination System (CTDS). CTDS was developed in 1992 and there was concern that the production rates used by the system were not always accurate. As a result many engineers were using their own experience and other outside sources to determine contract time. This study was important because it was one of the first studies to develop production rates based on crew days. Additionally, this study points to factors which can affect production rates.

This research team identified 23 work items to address in their study. These work items are shown in Table 2.1. Data was collected from TxDOT projects with durations greater than 120 days and less than 80% complete.

A total of 63 projects were selected across seven TxDOT districts to collect production data. These projects ranged in cost from $620,000 to $260 million. Data collection forms were developed and used to track production rates by collecting data such as the quantity and time used to complete a work item, and factors which affect productivity.

Table 2.1: Work Items Selected

Item No.		Item Description(s)
110		Excavation
132		Embankment
247		Flexible base
260		Lime treatment (road mixed)
276		Cement treatment (plant mixed)
340		Dense graded hot mix asphalt (method)
360	360-1	Concrete pavement (slip form)
	360-2	Concrete pavement (conventional)
409		Prestressed concrete piling
416		Drilled shaft foundations
420	420-1	Concrete structures - footing
	420-2	Concrete structures - column - rectangle
	420-2	Concrete structures - column - round
	420-3	Concrete structures - cap
	420-4	Concrete structures - abutment (cast in place)
423		Retaining wall - MSE wall
425		Precast prestress concrete structural members - beam erection
450		Railing - bridge railing
462	462-1	concrete box culverts and storm drains (precast)
	462-2	Concrete box culverts and storm drains (cast in place)
464	464-1	Reinforced concrete pipe (18-42 in.)
	464-2	Reinforced concrete pipe (48-72 in.)
465		Manhole and inlets
466		Head walls and wing walls
529		Concrete curb, gutter and combined curb and gutter
666/668		Pavement markings

Some of the factors affecting productivity identified during this research included:

1. project type and location

2. Traffic conditions

3. Weather (rain and length of winter)

4. Percentage of project completion

5. Contract amount

6. Technical complexity

7. Accelerated construction provisions

8. Liquidated damages

9. Subsurface conditions

10. Land slope

11. Work schedule (hours/day and days/week)

12. Contractor's management system

It was determined that the production rates calculated were based on the formula of "total crew workdays/total output." The quantity of work completed over time was measured in terms of total output with a unit of each (EA). This required minimal effort to measure the output and enabled quick measurement of work quantities. This would produce a production rate with units of "crew days/footer" instead of a production rate with "crew days/cubic yard of concrete."

Production rates were then corrected for delays by measuring time in the following manner:

- If a delay was experienced which amounted to less than 2 hours, Day = 1 day

- If a delay was experienced which amounted to less than or equal to 5 hours and greater than 2 hours, Day = 0.5 days
- If a delay was experience which amounted to greater than 5 hours then the day was counted as a non-workday.

If a workday had more than 2 hours of overtime it was to be adjusted based on actual overtime hours; however, no such overtime was observed.

After adjusting production rates for delays, it was intended that the production rates would be adjusted for crew size as well. It was observed that the crew sizes did not vary greatly from project to project on footing, pier, and column activities. It was also found that larger crew sizes did not necessarily lead to higher production rates. In most cases, the crew size had an insignificant impact on production rates. A possible explanation for this observation could be that larger crew sizes lend more help to deal with larger scale activities and more complex activities but do not help achieve a greater rate of production (O'Connor 2005).

It was also found that most estimators do not have information about crew sizes for different activities when contract time is being determined. For this reason, empirical production rates which vary due to crew size may not be useful to contract time estimators and as long as it is known the production rates do not vary greatly due to crew size, it was thought best not to constrain estimators to needing crew size information to determine contract time.

After production rates were formulated, a statistical analysis was performed to compare the newly developed production rates with those currently being used by CTDS. Differences in the scope of work defined under each set of production rates were

considered as well as differences in units used in the production rates. It was found that there were significant differences between the two sets of production rates.

2.3.3 Florida DOT

Herbsman and Ellis (1988) established contract duration estimating methods based on production rates for the Florida DOT. This study was important because it presented three different methods by which production data could be obtained. Each method is based on historical information or contractor experience and should be reliable methods for obtaining production data. The three methods of data collection presented were investigating other state departments of transportation, surveying existing Florida DOT projects, and interviewing contractors.

The first method of data collection, surveying other state departments, proved successful. This survey was conducted not only to collect production rate data, but also to determine what trends existed for estimating contract time. The production data obtained was evaluated and used.

The second method of data collection, surveying existing Florida DOT projects, required a field study. Florida DOT personnel participated in the study. This included project engineers and inspectors. They were given a survey form and asked to monitor and record:

1. The type of work activity being monitored
2. The quantity of material being placed on the job that day
3. The length of time required to place the material
4. The factors which could have an effect on the daily production rate.

This process was performed and data for 17 work activities was collected.

Production rate data was also obtained by surveying Florida DOT contractors. A number of experienced and knowledgeable contractors were identified and the researchers conducted confidential interviews with them.

After production data from all three methods was collected, it was compiled to produce a single production rate for each work activity. It was found that many of the production rates the Florida DOT was currently using were unsuitable. The newly developed production rates were incorporated into the Florida contract time determination calculations.

2.3.4 Memorial Bridge Production Rates

During the spring of 2005, a retrospective analysis of a VDOT bridge reconstruction project was performed. The project was located in Radford, VA, had an estimated cost of $22 million, and took four years to complete. A retrospective analysis is traditionally how the construction industry obtains time and work quantity data and other needed information from a project. This analysis included looking through project records, such as individual daily diaries, meeting minutes, photographs, and weekly/monthly progress reports. During this analysis, the completed project records were examined to collect durations and quantities of work from activities defined from a contractor CPM schedule to produce a set of average production rate data to place in a database designed to store production rate data.

It was found that the large amounts of project records made the retrospective analysis difficult and time consuming. The project records contained an estimated 7000

individual daily diary entries, as well as other forms of project documentation. Many times the project daily work reports were confusing and additional information was needed. For example, the contractor would often discontinue work on an activity for several weeks before resuming work on the activity. This made it difficult to trace activities through the project construction phase. On several occasions, the project inspectors were contacted to gain additional information. From this and similar undertakings, it was determined best to collect data contemporaneously, rather than retrospectively.

This conclusion was consistent with the conclusion of Popescu (2005). She recounted the process through which an as-built schedule was developed for a $790 million, petrochemical plant with a 2 year construction period. There was over 20,000 records comprising more than 175,000 pages. The documents were reviewed and existing as-built schedules were corrected for deficiencies. Missing scope was added and logic deficiencies were corrected in the existing as-built schedules.

Popescu stated, ". . . the development of the as-built schedule took an average of 1.4 man-hours per final schedule activity." The final schedule included 1003 activities and so, 1404 hrous were used. This is approximately 35 wks or nearly 9 months of work for one person to perform. Popescue recommended that project schedules be statused until the project is 100 percent complete and that data for the schedules be collected contemporaneously.

2.4. How Contemporaneous Data is Collected

Records are kept on a construction project for many reasons. Some of these reasons include historical purposes, job control, use as future estimating and bidding guidelines, and evidence for dispute resolution and claims analysis (Pogorilich 1992). It is important that all these records be kept contemporaneously to improve the accuracy of the records. Often the records do not contain enough detailed information to analyze claims (Knoke 1996). For this reason there have been many papers written regarding the contemporaneous collection of data for claims analysis. This data usually includes data to produce an as-built schedule with appropriate detail. This data is similar to performance data and the process for collecting the data can be considered to be the same. There are many possible ways performance data can be gathered contemporaneously. This research considered two possible methods, data collection with bar charts and data collection using a database.

2.4.1 Contemporaneous Data Collection with Bar Charts

Hegazy et al. (2005) presented innovative ways of using intelligent bar charts to collect data contemporaneously in an approach which is more user friendly than the traditional daily site records. Traditionally, data collected from the site are recorded in paragraph form. These documents are then either stored in a computer or in physical form and require someone review the documents to obtain information. If the necessary information could be recorded in a bar chart, it could be used to easily produce accurate as-built schedules for claim analysis. The authors presented two ways in which this could be done:

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1. As seen in Figure 2.1, a bar chart of this nature can be used to update the status of a project on a daily basis. Four conditions can be recorded for measuring the time spent per day on each activity:

    1. X = Activity was worked on all day

    2. W = Activity was not worked on for the entire day due to weather

    3. H = Activity was worked on for half a day

    4. R = Activity was not worked on for half of a day due to weather

2. As seen in Figure 2.2, a bar chart can be made with a computer spreadsheet with each cell representing a day. As was the case with the previous bar chart, this bar chart can be used to update the status of a project on a daily basis. Different from the previous bar chart, this bar chart can contain more information. In addition to recording the actual days an activity was worked on, the percent completed that day or quantity placed could also be recorded, as well as the actual cost to date. Comments can be attached to the cells to describe delays and their causes. Additionally, CPM logic can be linked to this bar chart to keep the user from committing errors. For example, if the user was updating the schedule and entered in a percent complete for an activity in which its predecessors were not completed, a logic violation warning would appear.

Code	Activity Description	Jun-90														
		5	6	7	8	9	12	13	14	15	16	19	20	21	22	23
E101	Excavate topsoil															
E102	General Excavation	X														
E103	Excavate pier		X	R	X											
E104	Excavate S abut					X										
E105	Excavate N abut					X	H									
E106	Backfill S abut					H	X									
E107	Backfill N abut															
S101	Blind S pier								W	H		H				
S102	Blind N pier								X	W	H	X	X	X	H	
Legend:	X: Activity working all day								H: Activity working half day							
	W: Activity not working all day due to weather								R: Activity not working half day due to weather							

Figure 2.1: Bar Chart used to Record Site Data (Hegazy et al. 2005)

Actual Progress Bar Chart

ID	Activity Description	Actual Cost To Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Excavation	$2,000	25.0%		0	25.0%	50.0%											
2	Foundation	$9,000			25.0%	C	25.0%	25.0%	50.0%									
3	Joining Wall	$6,000							100.0%									
4	House Walls	$1,000									1.0%	99.0%						
5	House Roof																	
6	Select Finishes																	
7	Interior Finishes																	
8	Clean Up																	
9	Fab. Garage Doors												2.0%	5.0%	5.0%	15.0%		
10	Garage Walls	$1,000									70.0%	5.0%						
11	Garage Roof																	

Progress Date

Figure 2.2: Spreadsheet Bar Chart (Hegazy et al. 2005)

2.4.2 Contemporaneous Data Collection Using a Database

Knoke and Jentzen (1996) suggest developing a database to contemporaneously store all the necessary data required to produce an as-built schedule. A portion of a typical as-built schedule database can be seen in Figure 2.3. The database would contain one record for each day for each activity which work was performed. A database could contain whatever details desired, but the database designed by Knoke and Jentzen included the date, description of work (activity), task code, and the subcontract under which the work was performed.

Date	Work Description	Task Code	Subcontract
1-May-09	construct equipment formwork	FNDN	Concrete
2-May-09	construct equipment formwork	FNDN	Concrete
3-May-09	construct equipment formwork	FNDN	Concrete
4-May-09	construct equipment formwork	FNDN	Concrete
4-May-09	place embedded conduit in equipment	CONDUIT	Elec
5-May-09	construct equipment formwork	FNDN	Concrete
5-May-09	place embedded conduit in equipment	CONDUIT	Elec
5-May-09	place embedded conduit in equipment	EQUIP	Mill
6-May-09	place equipment frame	FNDN	Concrete
7-May-09	construct equipment formwork	CONDUIT	Elec
8-May-09	place embedded conduit in equipment	FNDN	Concrete
9-May-09	cure concrete equipment foundation	FNDN	Concrete
10-May-09	cure concrete equipment foundation	FNDN	Concrete
11-May-09	cure concrete equipment foundation	FNDN	Concrete
12-May-09	cure concrete equipment foundation	FNDN	Concrete
13-May-09	strip concrete equipment foundation	CONDUIT	Elec
13-May-09	install exposed conduit to equipment	CONDUIT	Elec
13-May-09	install exposed conduit to equipment	EQUIP	Mill
14-May-09	install & align equipment	CONDUIT	Elec
15-May-09	install exposed conduit to equipment	EQUIP	Elec
16-May-09	install & align equipment	EQUIP	Mill
17-May-09	install equipment wiring	EQUIP	Mill
18-May-09	test & startup equipment	STARTUP	Startup
19-May-09	test & startup equipment	STARTUP	Startup
20-May-09	test & startup equipment	STARTUP	Startup
21-May-09	test & startup equipment	STARTUP	Startup

Figure 2.3: Segment of Typical As-built Schedule Database, AACE permission see

pg. 102, (Knoke 1996)

2.5. *SiteManager* as a Possible Contemporaneous Data Collection Tool

SiteManager is a client/server based construction management tool which was developed under the sponsorship of the American Association of State Highway and Transportation Officials (AASHTO). This software is part of the Trns·Port suite of products available through AASHTO, which includes PES (Proposal and Estimates System), LAS (Letting and Award System), DSS (Decision Support System), and CAS

(Construction Administration System). This easily allows for data to be integrated and transferred between the different software in the suite (AASHTO 2004)

Virginia was one of the first states to participate in the original development process of the *SiteManager* software and it is the system VDOT now uses. This system can be used by all levels of construction personnel such as field inspectors, technicians, project managers, clerks, auditors, lab personnel, management, producer/suppliers, contractors, and the FHWA (Gosaie 2005). *SiteManager* has many functions, but the three main functions are administering the contract, performing the daily processes, and paying the contractor.

2.5.1 Administering the Contract

On the main panel of the *SiteManager* software, the Contract Administration tab can be selected. Under this tab, the contractor's payment schedule can be monitored, payrolls can be documented, reports can be generated to assist in monitoring a contract, and reference data for vendors, subcontractors, and bid items can be input. Additionally, a construction contract can be:

1. Initialized – a new contract can be entered into the system. A contract will have a contract identification number, state or federal project number(s), and pay code number(s). It can also be specified what district and residency the project will take place in. The contract amount and contract time are also specified. Other important contract information can also be recorded such as amount of liquidated

damages, critical contract dates, primary personnel on the project, and the prime contractor and their insurance and bonding companies.

2. Reviewed – after a contract is initialized, various VDOT personnel will review and update the information. Because construction projects are dynamic, there are often plan discrepancies, disputes and claims, design issues, etc. which require additions or changes to a contract. These issues are recorded under the contract administration tab.

There are several reports which can be generated under the contract administration tab. These reports include the contractor status report, item quantity report, item work report, claim/dispute summary report, and contractor schedule report.

1. The contractor status report shows key contract dates which have been achieved such as letting date, notice to proceed date, work began date, substantial completion date, etc., as well as a breakdown of payments to the contractor.

2. The item quantity report shows the quantity placed and total amount paid for every bid item which was selected to show up on the report. The item work report shows the dates and quantities a single bid item was paid for. This report will only show one bid item at a time.

3. The claim/dispute summary report shows a summary of claims or potential claims on the selected project.

4. The contractor schedule report shows the projects on which a selected contractor is a certain percentage or more behind schedule.

2.5.2 Daily Processes

On the main panel of the *SiteManager* software the Daily Work Reports tab can be selected. Under this tab:

1. Daily work reports can be generated. A daily work report captures the details of the work performed on the day the report is created. It contains information regarding weather, temperature, inspector remarks, contractors on site, contractor personnel, contractor equipment, inspection staff personnel, work item quantities placed, and force account information.

2. A project diary can be generated. After a daily work report has been generated by project inspectors, they are submitted to the project manager for review. The project manager reviews the daily work reports and either accepts or returns it for improvements and resubmission. After all the daily work reports have been accepted, the project manager can write a diary summarizing the work performed on the project for the given day.

2.5.3 Paying the Contractor

On the main panel of the *SiteManager* software, the Contractor Payments tab can be selected. Under this tab an estimate can be generated. It is first necessary for a contractor to submitted his certified payroll, key dates (including project completion date) be updated, retainage amount be entered, and the installed work report be generated and reviewed for accuracy. An estimate can then be generated to allow a contractor payment

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for work performed in the past estimate period. Adjustments to estimates which have already been generated can also be made and incentives and disincentives can be paid.

There are various reports which can be generated from the contractor payment tab. These reports include the summary by funding report and the installed work report. The summary by funding report provides a breakdown of each estimate. The installed work report shows the quantity and date of each bid item entry made while completing a work report. This list comprises every entry made from the time the last estimate was performed to the time the report was generated.

2.6. Statistical Analysis: Wilcoxon Rank Sum Test

Because this research performs a statistical analysis to ensure the data collected with *SiteManager* is reasonably accurate, literature on the Wilcoxon Rank Sum Test was reviewed. The Wilcoxon rank sum test is a nonparametric test. This test requires two independent random samples taken from two populations with distributions which are identical with the exception that one distribution may be shifted to the right of the other distribution. It is not required that both distributions be normal or that the variances be equal (Ott 2001).

Because this test does not require the distributions to be normal, many of the values may be extreme. This is dealt with by ranking the values from lowest to highest when both samples are combined. Thus, this eliminates the strong effect of extreme values on the rank sum statistic (Ott 2001).

The steps to perform this analysis are as follows:

1. Organize the two samples of data where the number of observations in sample 1 is less than the number of observations in sample 2

2. Combine both samples of data

3. List the data values from smallest to largest

4. Assign a rank from 1 to N for each of the data values with one corresponding to the smallest value and N corresponding to the largest value.

5. If there are two data values in the combined set of data which are duplicated, the average of the ranks for the duplicated observations are assigned as the rank.

6. For populations with small samples sizes (n_1 and $n_2 \leq 10$) sum the ranks of population 1. (T = sum of ranks of population 1) Use Table 2.1 to draw conclusions.

Table 2.1: Wilcoxon Rank Sum Test (Ott 2001)

H_o: The two populations are identical
H_a: 1. Population 1 is shifted to the right of population 2.
2. Population 1 is shifted to the left of population 2.
3. Populations 1 and 2 are shifted from each other.
For α = 0.05
R.R.: 1. Reject H_o if $T > T_U$
2. Reject H_o if $T < T_L$
3. Reject H_o if $T > T_U$ or $T < T_L$

7. For populations with large samples sizes (n_1 and $n_2 > 10$) sum the ranks of population 1. (T = sum of ranks of population 1) Use Table 2.2 to draw conclusions.

8. $\sigma_T^2 = \dfrac{n_1 n_2}{12}\left[(n_1 + n_2 + 1) - \dfrac{\sum_{j=1}^{k} t_j\left(t_j^2 - 1\right)}{(n_1 + n_2)(n_1 + n_2 - 1)}\right]$

where n_1 is the number of observations in sample 1, n_2 is the number of observations in sample 2, k is the number of groups of duplicated values, and t_j is the number of duplicated values in the jth group.

9. $\mu_T = \dfrac{n_1\left(n_1 + n_2 + 1\right)}{2}$

10. $z = \dfrac{T - \mu_T}{\sqrt{\sigma_T^2}}$

Table 2.2: Wilcoxon Rank Sum Text (Ott 2001)

H_o: The two populations are identical
 H_a: 1. Population 1 is shifted to the right of population 2.
       2. Population 1 is shifted to the left of population 2.
       3. Populations 1 and 2 are shifted from each other.
 	
 For $\alpha = 0.05$
 R.R.:   1. Reject H_o if $z \geq z_\alpha$
       2. Reject H_o if $z \leq z_\alpha$
       3. Reject H_o if $|z| \geq z_{\alpha/2}$

2.7. Summary

It was found during the literature review that two elements of performance data are required to develop production rates, quantity and time. In addition to this, research sponsored by TxDOT suggests that production rates need to be calculated per crew. For this reason performance data will include the daily installed quantity and the number of active crew days for each activity. There are various levels of detail by which quantity

and time can be measured. In order to produce the most accurate results, quantity should be measured in terms of units completed and time should be measured by attributing a full day to any activity on which work was performed.

There are many different ways to collect performance data. The research performed for the Florida DOT collected data by investigating other state transportation agencies, interviewing contractors, and surveying ongoing Florida DOT projects. The most established method, however, is surveying ongoing projects.

The data collection process can be performed either retrospectively or contemporaneously. The study performed as well as the literature reviewed overwhelmingly suggests it is best to collect data contemporaneously.

There are many different methods one can use to collect performance data contemporaneously. One can either manually or digitally record the data on bar charts, or a database could be developed to store this information. *SiteManager* was chosen as the tool for performance data collection for this research.

Chapter 3: Preliminary Evaluation of *SiteManager*

3.1. Intended use for *SiteManager*

The *SiteManager* software was created to track a construction contract and the work being performed under this contract. It is essentially a construction accounting system used to keep a record of the work performed by a contractor, quantities of bid items placed by a contractor, and to authorize payment for the quantities placed to the prime contractor. Because of these reasons, it was necessary to perform a preliminary evaluation of *SiteManager* to determine whether it could be used for collecting the daily installed quantity (DIQ) and active crew day (ACD) performance data. Various data collection methods were contrasted showing *SiteManager* to be the most feasible option of collecting performance data. The preliminary evaluation then addressed the following points:

1. Can *SiteManager* be used to collect performance data?

    a. Can performance data be collected for activities?

    b. Can the quantity of work placed during an activity be tracked?

    c. Can the time required to complete the activity be tracked?

2. How is data extracted from *SiteManager*?

3. Are there any identifiable problems with collecting performance data with *SiteManager*?

3.2. Obtaining Performance Data

A feasible method of collecting performance data was needed. Various potential methods were identified for contemporaneously collecting performance data from VDOT projects:

1. Using *SiteManager*
2. Using Data Collection Forms
3. Interviewing Inspectors and Contractors
4. Using Custom Software

3.2.1 Using *SiteManager*

One of the first methods identified to collect performance data involved using *SiteManager*. Project inspectors already used *SiteManager* to document the construction process, administer a project, and pay the contractor. This method required project inspectors to record performance data under the bid items tab of the software. Inspectors would simply enter the resulting quantity of work performed for each DBI on a daily basis. When the contractor would work on a DBI and no quantity resulted, the inspector would record a zero and when the contractor worked and a quantity resulted, the inspector would record the actual quantity the inspector placed. The advantages of this method are:

1. *SiteManager* was already being used by project inspectors and it is on every project inspector's computer
2. It is easy to understand
3. It is easy to implement

4. It does not require double entry (once by Inspectors into *SiteManager* and secondly by inspectors into an alternate data collection tool) and therefore reduces the amount of time and resources required to collect performance data. This reduces the additional work load on project inspectors.

The disadvantages of this method are:

1. Project Inspectors dislike the *SiteManager* software and have some resistance to changing the way they use the *SiteManager* software.

2. It would rely on the availability of a computer and the *SiteManager* software

3. The process of approving modifications to the software in order to collect additional data, different data, or provide greater ease of use may be difficult

3.2.2 Using Data Collection Forms

One of the methods of collecting performance data was developing data collection forms for project inspectors to use to collect performance data. This method involved requesting project inspectors to daily record the resulting quantity for each DBI work was performed and the number of crews required to perform the work. If zero quantity resulted during a day when work was performed on a DBI, a zero would be recorded. The form would also contain all the necessary project information. The advantages of this method are:

1. The form would be easy to adjust to encompass the unique set of DBIs for each project

2. No software training would be required

3. It is easy for inspectors to understand

4. It would not rely on the availability of a computer or certain computer software

The disadvantages of this method are:

1. Causes a need for triple recording of some data. Once by the inspector into *SiteManager* software, second by project inspector onto the data collection form and third by an administrator into the database.

2. Creates extra paper work

3. Paper can be lost or destroyed

4. Extra time is required for administrator to deliver and retrieve data collection forms to and from multiple projects.

3.2.3 Interviewing Inspectors and Contractors

Another method of collecting performance data was interviewing inspectors and contractors. This could be done on either a daily or a weekly basis to determine what DBIs were worked on for the time period, how many days during the week the DBI was worked on (if interviewed weekly), how many crews worked on the DBI during each day of activity, and how much quantity was placed for each DBI. The advantages of this method are:

1. It would be easy to modify in order to collect additional data or different data

2. It does not require any additional work by project inspectors

3. It would not rely on the availability of a computer or certain computer software

The disadvantages of this method are:

1. It introduces a need for additional personnel to make site visits and conduct the interviewing process.

2. Difficult to implement because of the additional personnel required

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3. It relies on the memories of site personnel to recount the activities of the past week or chosen time period

3.2.4 Using Custom Software

A fourth method of collecting performance data involves creating custom software to place on the computers used by project inspectors. This software could be developed to allow the collection of any desired project information and can be tailor made to easily collect performance data. This software could specify the DBIs for each project type and allow inspectors to collect performance data for the DBIs which are available on their project. This method would require project inspectors to daily record performance data with the custom software. The advantages of this method are:

1. It would most likely be easy for inspectors to understand and use

2. There would be no process of approving modifications to the software. VDOT would own the software and have the right to modify it in any way desired.

The disadvantages of this method are:

1. It would be difficult to implement because the software would have to be installed on every inspector's computer

2. It would rely on the availability of a computer and the computer software

3. Causes a need for double recording of some data (once by the inspector into *SiteManager* and second by the inspector into the custom built software). For this reason additional personnel may be required to retrieve the performance data and enter it into the database.

3.2.5 Essential Aspects of the Data Collection Method

Because it was believed each data collection method would collect the required performance data, there were additional aspects which were developed and considered essential the data collection method contain. These aspects were as follows:

1.   Method must be easy to understand

2.   Method must be easy to implement

   a. Required data collect tools must be available

   b. Required data collection tools bust be easily disseminated to the inspectors

   c. Collected data must be easy to obtain

3.   Method must not significantly increase the inspector's workload

4.   Method must not significantly increase the need for additional personnel

Table 3.1 summarizes the results of the evaluation of the four methods of data collection when considering the four essential aspects.

Table 3.1: Data Collection Method Evaluation

Data Collection Methods	Understandable	Ease of Implementation	Increase Workload	Increases Personnel
Using *SiteManager*	Yes	Yes	No	No
Using Data Collection Forms	Yes	No	Yes	Yes
Using Custom Software	Yes	No	Yes	Yes
Interviewing Inspectors and Contractors	Yes	No	No	Yes

As can be seen from the table, the use of *SiteManager* is easy to understand, easy to implement, does not significantly increase the inspector's workload, and does not require

any additional personnel. It was not considered detrimental that the use of *SiteManager* to collect performance data relied on the availability of computers to collect performance data because every VDOT project inspector is provided with a computer and the *SiteManager* software. For this reason the data collection tool, *SiteManager*, was easily obtainable and did not have to be disseminated to the inspectors.

Additionally, it was known the process of approving modifications to the software in order to collect additional data, different data, or provide greater ease of use may be difficult. However, even though it may be difficult, it is possible that modifications can be made if they are required. Thirdly, it was known that inspectors dislike the *SiteManager* software and may resist changing the way in which they use *SiteManager*. This is a disadvantage which all performance data collection methods may experience and it was not considered to be essential for a data collection method. Because of these reasons, the use of *SiteManager* was considered to be the most logical option to collect performance data.

3.3. Can *SiteManager* Collect Performance Data

To ensure *SiteManager* could be used as a tool to collect performance data, it was necessary that *SiteManager* have the ability to collect the DIQ and ACD. This required that *SiteManager* have a method to collect data for activities and collect both the quantity of work placed and the time used by each crew to place the quantity of work for activities. If *SiteManager* had these abilities, it could be considered a feasible option for collecting performance data.

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3.3.1 Can Data Be Collected For Activities

In order to collect performance data, it was required that activities be defined and used to collect the DIQ and ACD data. *SiteManager* was not designed to define activities and track the time required to complete the activities. *SiteManager* tracks bid items and the quantity of the bid items placed during construction. This data is currently used to monitor the progress of a contract.

The Partnership defined activities to be used in this regard. Because *SiteManager* only tracks bid items and progress is monitored using quantities of bid items installed, it was determined that each activity needed to have a list of driving bid items (DBI) associated with them. A DBI is a bid item which is significant to the completion of a project and the measurement of a DBI is a reflection of project progress (Williams 2006) Because DBIs were defined, *SiteManager* had the capability of collecting performance data for activities.

3.3.2 Can Units of Work Be Collected

SiteManager can be used to collect the quantity of work placed for driving bid items. There was no required modifications to either the *SiteManager* software or the procedures currently being used to operate the software to collect this element of performance data. A *SiteManager* user currently enters the installed quantity for bid items so that the contractor can be paid.

3.3.3 Collection of Units of Time

Because *SiteManager* was intended to track the DIQ, not the time required to place the quantities, tracking the duration of activities was more difficult in *SiteManager* than tracking the quantity of work placed for an activity. One could determine the duration of an activity by reading the general comments recorded on each daily work report. This, however, would not be any different than analyzing a project retrospectively to obtain the required DIQ and ACD information. It was not desired to analyze a project in this way because of the amount of time and effort required, as well as the loss of accuracy.

A method was developed to collect the duration of an activity in *SiteManager* without requiring a person to read the general comments in a daily work report. This method did not require any modifications to be made to the *SiteManager* software. It did require modifications to be made to the method by which a user would fill out a daily work report.

The method developed required the *SiteManager* user to enter a quantity in the "placed quantity" field of the work items tab of a daily work report. This quantity was:

- Zero, if there was work performed on a DBI but no quantity resulted. This would be the case if, for example, forms were built for a concrete footer but no concrete was placed in the footer.

- The quantity of work installed, if there was both work performed on a DBI and a quantity was installed. This would be the case if concrete was placed into the footer forms for a concrete footer.

The duration of a DBI would be equal to the count of all the number of entries made for the DBI and the quantity of work placed for a DBI would be the sum of the quantity placed for the DBI. This method allowed *SiteManager* to have the ability to track the duration of DBIs.

3.4. Performance Data Accuracy

It was assumed that the DIQ and ACD based on actual construction events would develop accurate performance data. This changes the question from, "are the DIA and ACD accurate," to, "can *SiteManager* produce data which accurately represents the actual construction events?"

From a preliminary standpoint, it appeared as though data obtained from *SiteManager* using the current methods of use would not accurately provide performance data in the desired way. This was because there was no consideration of time. If modifications were made to the methods by which *SiteManager* was used, it appeared as though the data would accurately represent the actual construction events. This was because if modifications were made, all time required to perform work on a DBI would be tracked and if no modifications were made, this time would not be tracked. The only apparent reason for inaccuracy when modifications were made was data entry errors.

3.5. Technical Aspects of Transporting Data into BIDDS

In order to prevent double entry of data, first into *SiteManager* and second into BIDDS, it was necessary to automate the process of transporting the data from *SiteManager* into BIDDS. BIDDS is a Microsoft Access database and had limitations on the way data was imported. It was known that the data would need to have a text (.txt)

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file type for import into bids. Because BIDDS was under construction at the time the preliminary evaluation was performed, the exact data format was not known. It was known that the required fields were:

1. The State Project Number

2. Bid Item Number

3. Month Performed

4. Year Performed

5. Quantity Placed

6. Number of Days Performed

It was found that when a report is generated in *SiteManager*, it can be exported as a text file type. It was assumed that either a report could be found or a report could be created which contained the necessary data required for the format needed to import data into BIDDS. If the data exported from *SiteManager* needed to be reformatted before importing it into BIDDS, a Microsoft Excel macro could be created to reformat the data.

3.6. Summary

SiteManager was created to document construction projects, administer contracts, and did collect the DIQ not to collect the ACD. It was found, however, that when modifications are made to the use of *SiteManager*, performance data could be collected. Because DBIs were defined and associated with activities, when *SiteManager* is used to collect performance data for DBIs, data is being collected for activities. *SiteManager* was appropriately used to collect the quantity of work produced. Additionally, when

inspectors entered resulting daily quantity for a crew for each bid item, each entry counted as an ACD for a DBI, and time could be collected.

These methods addressed all the known identifiable problems with collecting performance data using *SiteManager*. It was believed that these modifications were required to collect accurate performance data because the current method of use did not account for the amount of time required to install a quantity of work.

Data can be extracted from *SiteManager* by generating reports. These reports can be exported from *SiteManager* in the form of a text file. It was believed that either a report could be found or a report could be created which would contain all the performance data required by BIDDS.

Chapter 4: Design of Field Study

4.1. Introduction

In order to meet the objectives, the field study was designed to:

1. Ensure performance data could be collected

2. Collect data to perform a statistical analysis of data accuracy

3. Provide data so that methods could be developed to meet the technical requirements to import data into BIDDS

SiteManager was analyzed and methods were developed to ensure that *SiteManager* had the ability to collect performance data. This was so that the feasibility of *SiteManager* use as a data collection tool could be determined. A statistical analysis was designed to determine if the data obtained through use of *SiteManager* would accurately represent the actual construction operations. Methods were also designed to meet technical requirements for import of data into BIDDS.

4.2. Design of Data Acquisition Using *SiteManager*

There are many VDOT personnel who use *SiteManager* daily to perform various functions. The only personnel who complete a daily work report within *SiteManager* are the project inspectors and the project managers. These are the VDOT personnel who are assigned to construction projects and document the construction process. For this reason, the field study was designed for project inspectors and project managers to collect and enter performance data into *SiteManager*. In order to further acquire data, performance

data collection methods were designed and criteria for projects to implement the designed methods were established.

4.2.1 Performance Data Collection Methods

The methods designed for data collection were identified during the preliminary evaluation. DBIs associated with activities were defined by the Partnership. The scope of work for each one of the activities was defined. This list of definitions can be found in Appendix A. This was defined to eliminate any ambiguity for project inspectors about what work to track under a specific DBI and what work was outside the scope of a specific DBI. Prior to data collection, inspectors would be given a list of the activities for their project type and the associated DBIs which were in the project contract. On each day when work was performed, the inspector would identify which DBI would best describe the work being performed. The inspector would record any performance data performed under the identified DBI.

This would be done by initiating a daily work report. The inspectors must fill out at least one daily work report for each project per day. In the daily work report, the inspector would enter any performance data under the work items tab. The inspector would select the identified DBI and enter the resulting quantity of each crew working on the DBI placed. The quantity is entered in the "Placed Quantity" field of the work items tab of a daily work report. For each crew working on a DBI, the quantity entry would be:

- Zero, if there was work performed on a DBI but no quantity was placed.
- The Quantity of Work Placed, if there was work performed on a DBI resulting in an installed quantity.

If there was more than one crew working on a DBI, then there would be more than one quantity entry made for that day for that DBI.

4.2.2 Extracting Data From *SiteManager*

It was discovered that all the performance data required by BIDDS could be found in the Installed Work Report which *SiteManager* generates. This eliminated the possible need for creating a report which contained the necessary performance data. The required performance data includes:

- State Project Number

- Bid Item Number

- Month Performed

- Year Performed

- Monthly Quantity

- Number of Days Performed.

The report can be exported into a text file which can be read by Microsoft Excel. An example of data from this report can be seen in a table in Appendix B. It contains one row for every bid item entry made on the work items tab of a daily report. Each entry, or row, on the installed work report includes the project number, the bid item number, the date the entry was made, and the quantity entered. The data in this report did not meet the technical requirements to import the data into BIDDS because of formatting issues.

4.2.3 Project Selection Criteria

There were several issues associated with the selection of project. The projects needed to be close enough that site visits could be performed to initiate the data

collection procedure, periodically answer questions, and monitor the data collection progress. The data collection took place during the winter months, September through December. There was a possibility that there would not be enough work to take place. In order to overcome these issues, the following criteria was developed:

- Only projects within the Salem and Staunton Districts would be considered. This was due to the proximity of the districts.

- Only typical VDOT projects with substantial work to be completed through the winter months would be selected.

4.3. Design of Statistical Analysis

The purpose of performing a statistical analysis was to provide confidence in the fact that the data being obtained through the use of *SiteManager* accurately modeled the actual events which were being recorded. In order to make such a comparison, performance data needed to be collected using three different methods.

1. Data needed to be collected with *SiteManager* when the methods of use were modified to include the designed performance data collection procedures.

2. Data needed to be collected using *SiteManager* when no modifications were made to the way the system was used.

3. Control data accurately representing actual construction events needed to be collected.

After the data was collected using these three methods. For all three methods, the weekly

sum of DIQ was divided by the weekly sum of ACD $\left(\dfrac{\sum DIQ}{\sum ACD} \right)$ to produce the average

daily crew output (ADCO) and three different comparisons were made.

1. The ADCO produced from data collected through the use of *SiteManager* after modifications were made, was statistically compared with the ADCO produced from control data. This was to ensure the data collected from *SiteManager* after modifications were made accurately represent actual construction events.

2. The ADCO produced from data collected through the use of *SiteManager* with **<u>no</u>** modifications was statistically compared with the ADCO produced from control data. This was to test if the current methods through which *SiteManager* is used can accurately model actual construction events.

3. Finally, results from the first statistical analysis were compared with the results from the second statistical analysis and conclusions were drawn.

In this way, every project selected used two of the data collection methods to collect data.

Every selected project collected control data and collected data using one of the two

SiteManager data collection methods. This ensured every project had a record of data

collected with *SiteManager* and a record of data which accurately represented the actual

construction events.

4.3.1 Obtaining a Record of Actual Events for Control Data

In order to obtain an accurate record of performance data based on the actual

events on construction projects, a data collection form (DCF) was created. An example

of a data collection form can be found in Appendix C. The inspectors on a project were given a DCF which was unique to their project. The DCF contained all of the project information such as the project number, route number, project type, district and county, project description, and project award amount which applied to their project. It also contained all the predefined activities and their associated DBIs which were required to complete the work for the project. For each day an activity was worked on, the inspector would select the row containing the DBI which best represented the work being performed and record the quantity of work in this row along the column containing the date the work was performed. This would, in effect, create an as-built chart with quantities. The project inspectors would also record the start and finish dates for each DBI and the total quantity placed. This data was considered to accurately represent the actual construction events.

It would not allow any typing mistakes and, with exception of data collection mistakes, any unwanted data would not become part of the record. This method was termed the manual method. All data obtained though the use of *SiteManager* was compared to the manually collected data.

4.3.2 Data Sampling

The data for this project was extracted from *SiteManager* on a monthly basis at the time the project monthly estimate was due. This was done because the installed work report includes only present data from the date the last monthly estimate was performed to the date the report was generated. The time a monthly estimate was due differed for the different projects and for this reason, the monthly estimate was generated at different

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times. When a monthly estimate was ran depended on the contractor's name. According to section 109.06 of the VDOT road and bridge specifications (2002), if the contractor's name is between A-F, the monthly estimate would take place on the 4th of the month, G-P, the monthly estimate would take place on the 11th of the month, or Q-Z, the monthly estimate would take place on the 20th of the month. The installed work report was generated prior to the monthly estimate being performed. It was then analyzed to identify the DBIs and extract the DIQ and ACD data.

After the data was extracted from *SiteManager*, it was divided into weekly increments and the ADCO was calculated for each week a work item was active. Dividing the data into increments of weeks instead of increments of months was chosen to produce more data points to be used for the statistical analysis and increase the sample size. The ADCO was calculated by using the total quantity of work produced during the week divided by the total amount of crew days per week.

4.3.3 Data Organization

There were two types of projects observed during this research. Type I collected data using *SiteManager* when modifications had been made to the way *SiteManager* had been used. Type II collected data using *SiteManager* when no modifications had been made to the way *SiteManager* had been used. Additionally, both types of projects produced control data by collecting data using the manual method of data collection.

Because the methods of data collection for the Type I projects were the same, the data from these projects was compiled. If there were DBIs present on these projects which were the same, they were compiled. All the data for each DBI collected using

SiteManager with modifications was compiled and all the data for each DBI collected using the manual method was compiled. This produced one distribution per DBI for both methods of data collection on the Type I projects. Each DBI had one distribution of average daily crew outputs calculated from data collected using *SiteManager* with modifications and one distribution of average daily crew outputs calculated from data collected using the manual method.

Similarly, because the methods of data collection for the Type II projects were the same, the data from these projects was compiled together. This produced one distribution per DBI for both methods of data collection containing on the Type II. Each DBI had one distribution of average daily crew outputs calculated from data collected using *SiteManager* with no modifications and one distribution of average daily crew outputs calculated from data collected using the manual method.

In this way, four sets of distributions were produced. The first set contained ADCOs from the Type I projects calculated from the data collected using *SiteManager*. The second set contained ADCOs from the Type I projects calculated from the data collected using the manual method. The third set contained ADCOs from the Type II projects calculated from the data collected using *SiteManager*. The fourth set contained ADCOs from the Type II projects calculated from the data collected using the manual method.

The first and second set of distributions, both from the Type I projects, were used to make the statistical comparison between the ADCOs calculated from the data collected through the use of *SiteManager* after modifications were made and the ADCOs calculated from the manual collection method. The third and fourth set of distributions,

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both from Type II projects, were used to make the statistical comparison between the ADCOs collected through the use of *SiteManager* with **no** modifications and the ADCOs calculated from the manual collection method.

4.3.4 Methods of Statistical Analysis

After the data was organized into four distributions, two statistical analyses would need to be performed. The first analysis would compare the two distributions of data collected from Type I projects and the second analysis would compare the two distributions of data collected from Type II projects.

Each distribution was comprised of all the data collected from every DBI for a single method. Each DBI contained different units of measurement and was therefore different in scale from other DBIs. For this reason, it was known that the every distribution would contain non-normal data and extreme values were expected.

It was expected the two distributions from data collected from Type I projects, projects where data was collected with modifications in *SiteManager* use, were identical. It was also expected the two distributions from data collected from Type II projects, projects where no modifications were made to the methods by which *SiteManager* was used, were not identical. This was expected because when no modifications are made to *SiteManager*, it does not account for the amount of time required to install a quantity of work. It was not known whether to expect the variances to be equal so it was assumed the variances would not be equal.

For these reasons a Wilcoxon rank sum test was chosen. This test assumes independent random samples with two identical distributions. The distributions do not

have to be normal and one does not have to assume equal variances. Additionally, by ranking the observations, extreme values do not have a strong effect on the rank sum statistic as they have on other tests.

Using this analysis the two distributions from Type I projects will be tested against the hypothesis that the two populations are identical. It is expected that this hypothesis can be accepted. The two distributions from Type II projects will be tested against the same hypothesis that the two populations are identical. It is expected that this hypothesis will be rejected.

4.4. Design of Data Transfer to BIDDS

As specified by BIDDS, the data file format required to properly import performance data into the database appears as shown in Table 4.1. The column headings will not be part of the data table being imported into BIDDS. Only the data, formatted as shown in Table 4.1, in grey will be part of the imported text file. This is a different format than the data exported from the *SiteManager* installed work report.

Table 4.1: Data Import File Format

Project Number	Bid Item Number	Month Performed	Year	Total Monthly Quantity	Total Number. of Crew Days
SD 0001	00100	9	2001	1	4
SD 0001	10630	10	2001	1022	1
SD 0001	68320	10	2001	78	1
SD 0001	68330	9	2001	31	1
SD 0001	10607	9	2001	59	1
SD 0001	54020	10	2001	2156	1
SD 0001	00100	11	2001	1	4
SD 0001	10630	10	2001	533	1

Because the format of the data exported from *SiteManager* and the required format of the data to import into BIDDS differed, the data exported from *SiteManager* needed to be reformatted. This would require the data to pass through some medium which would convert the data from the *SiteManager* format into data formatted for BIDDS. The medium selected for this research was a macro created in Microsoft Excel called *SiteManager* Data Converter (SMDC). A macro is series of commands and instructions (in Microsoft Excel for this case) that are grouped together as a single command to accomplish a task automatically. The commands and instructions are written in Visual Basic for Applications code.

Furthermore, the data contained in the installed work report includes entries for both driving bid items and non-driving bid items. SMDC was given an additional task of converting only the DBIs into the format required for import into BIDDS. This would eliminate unneeded data from being imported into BIDDS and residing in the database. The SMDC process was designed to:

- Open an installed work report text file in Microsoft Excel
- Copy the project number and bid item number to a new file
- Identify the DBIs based off of the project type
- Sum the number of entries made per month to be equal to the number of crew days performed within the month
- Sum the total quantity placed per month
- Allow selection of the month performed and the year performed
- Save the new file as a text file.

Because the installed work report was chosen for this research, the report had to be generated and converted into the proper format on a monthly basis for each project. Each project inspector was asked to export an installed work report to be given to the researcher at the time an project estimate was ready to be generated, yet prior to completing the estimate.

4.5. Summary

In order to ensure performance data could be collected, performance data collection methods were designed. The intention was to collect time and quantity data for activities by collecting data for the DBIs defined by the Partnership. This would be done by collecting the resulting daily quantity installed by each crew, even if this quantity was zero. This design would produce one entry for each day work was performed by a crew on a DBI. The number of entries would equal the number of days and the sum of the quantity entered would be the quantity installed.

These designed procedures would be implemented on selected projects to begin collecting data. The collected data would be used to conduct a statistical analysis of data accuracy and provide data so that methods could be developed to meet the technical requirements to import data into BIDDS.

The statistical analysis would be performed data collected using the designed modifications to *SiteManager*, using *SiteManager* with no modifications, and using the manual method. This would allow for three comparisons to be performed. *SiteManager* with the designed modifications would be statistically compared with the manual data to ensure the modifications produce accurate data. *SiteManager* with no modifications

would be statistically compared with the manual data to ensure modifications are needed. The results of the two statistical analyses will be compared to draw conclusions.

Data will be extracted from *SiteManager* using the Installed Work Report. This report contains all the data required by BIDDS. To meet the technical requirements to import data into BIDDS, a data converter was designed to become a medium for the data to pass through to be sorted and reformatted.

Chapter 5: Conduct the Field Study

5.1. Introduction

After the field study was designed, the research procedures began. This involved setting up meetings with representatives from the Salem and Staunton districts to help initiate the data collection procedures. Projects were selected from these districts and the designed data collection process was implemented. The methods used to collect performance data with *SiteManager* by modifying its use were observed. During this process, data was gathered from the different data collection methods for the statistical analysis.

5.2. Project Selection

In order to facilitate project selection, representatives from the selected districts were contacted. A meeting was scheduled with these representatives to achieve five objectives:

1. Obtain permission to gather data

2. Obtain permission to make modifications to the methods by which *SiteManager* was used

3. Gain assistance in selecting applicable projects

4. Acquire access to the selected projects

5. Be assigned a district contact to introduce the researcher to the project inspectors and help initiate the data collection process

The selected projects ranged in size, but all were expected to have substantial work to be completed through the winter months. All projects selected were in the Staunton and Salem districts.

5.2.1 Projects in Staunton District

A meeting was scheduled with the Area Construction Engineers, Contract Administrator, and Construction Managers in Staunton District to discuss the selection of projects. These representatives gave the researcher permission to collect performance data and also make the proposed modifications to the *SiteManager* system. The Construction Managers were appointed as the district contacts for the selected projects. The Staunton representatives also assisted in selecting projects on which to collect data. The selected projects are as follows:

- Rte. 18 Project – A $1.48 million bridge reconstruction project in Alleghany County being constructed by Orders Construction Company, Inc. This project contained a small bridge over Blue Springs Run and the approaches. The project was 0.27 miles in length.

- Rte. 33 Project – A $1.7 million road reconstruction project in Rockingham County being constructed by Hammond-Mitchell, Inc. This project involved some minor widening and addition of drainage infrastructure. The project was 0.26 miles in length.

5.2.2 Projects in Salem District

A meeting was scheduled with the Area Construction Engineers, Project Controls Engineer, and Construction Managers in Salem District to discuss the selection of projects. These representatives gave the researcher permission to collect performance data on the selected projects. Due to difficulties being experienced with *SiteManager*, no modifications to the methods by which *SiteManager* was used were permitted. The Salem representatives determined they would wait and observe the experiences of the Staunton District with changing the methods of using *SiteManager* before considering making any modifications within the Salem District. They were concerned the modifications may negatively affect the monthly estimates. The Project Controls Engineer was appointed as the district contact for the selected projects. The Salem representatives also assisted in selecting projects on which to collect data. The selected projects are as follows:

- Rte. 81 Project – A $1.28 million bridge reconstruction project in Roanoke County being constructed by Fort Chiswell Construction Corporation. This project contained removal of medians, pavement widening, repairs to a bridge structure, and bridge overlay. The project was 0.4 miles in length.

- Rte. 601 Project – A $6.98 million road reconstruction project in Roanoke County being constructed by W-L Construction & Paving, Inc. This project involved 2.6 miles of grading, drainage work, utilities and a bridge.

- Rte. 11 Project – A $688,375.40 bridge reconstruction project in Montgomery County being constructed by Ranny E. O'dell & Company, Inc. This project

included the replacement of the superstructure and repair of the substructure on a bridge.

- Rte. 693 Project – A $869,084.30 bridge reconstruction project in Pulaski County being constructed by Fort Chiswell Construction Corporation. This project contained the demolition and replacement of a bridge.

5.3. Preparing the Data Collection Process

Prior to initiating meetings with the project inspectors, the materials required for each method to collect the required were prepared. These materials included developing a list of DBIs and a data collection form for each project. The list of DBIs were to present to the project inspectors so they would know which bid items performance data needed to be collected. The data collection forms were to facilitate the manual data collection process used on each project. For this reason, each project was analyzed to determine the project type, develop a list of the DBIs, and develop a data collection form.

5.3.1 Develop a List of DBIs

The list of DBIs was created by first understanding the components and scope of each project to accurately select the appropriate project type. The bid items for the project were compared with the DBIs for the selected project type to determine the list of DBIs for the project. These DBIs were then placed in a list along with their associated activities to be provided to project inspectors.

The DBIs were in the process of being determined and solidified during the time the selected projects were being analyzed. For this reason, each successive project which was analyzed had a newer, updated set of DBIs. This, however, did not affect the outcome of this research because the purpose of the data collection was not to obtain usable data but to evaluate the methods and use of *SiteManager* as a data collection tool. Even though the different projects may have used newer updated lists of DBIs, this did not compromise the data collection process which was being observed.

5.3.2 Develop Data Collection Forms

After the list of DBIs was developed, the data collection form was not difficult to create. The project information such as the project number, the district and county the project was located, the project award amount, the project description, and the project setting as well as the DBIs were placed into the designed data collection form. This form allowed the inspectors to daily collect performance data in the same manner they were recording the data in *SiteManager* using a means other than *SiteManager*. This data was being collected as the control data for the statistical analysis to compare with the data collected from *SiteManager*. It was considered to be data which accurately represented actual construction events.

5.4. Initialization of Project Data Collection

The appointed district contacts were contacted to assist in introducing the data collection process to the project inspectors. The purpose of the meeting was to explain the data collection process to the field personnel.

5.4.1 Projects in the Salem District

For the projects in the Salem District, the projects which collected data both manually and with *SiteManager* when no modifications were made, only the manual data collection process was explained. No explanation was required for collecting data with *SiteManager* because no modifications were made to the methods by which *SiteManager* was used. The inspectors were requested to record on the data collection form each day work was performed on a DBI. This was done by recording the resulting daily quantity for each DBI, even if this quantity was zero.

5.4.2 Projects in the Staunton District

For the projects in the Staunton District, the projects which collected data both manually and with *SiteManager* after modifications were made, both the manual data collection process and the modifications to the uses of *SiteManager* were explained. The manual data collect process was explained in the same way as it was explained for the projects in the Salem District.

The following instructions were given for collecting data by changing the way in which *SiteManager* is used:

1. All performance data will be collected in the daily work report under the work items tab. In current practice, this tab is used to track the daily quantity placed for each bid item. This practice will remain the same.

2. Different methods will be used to collect the number of days. This will not alter the sum of the total quantity placed. To collect this data, the following procedures are used:

a. When work is performed by a crew and a quantity results, One "Quantity Placed" entry per crew containing the resulting quantity is required

b. When work is performed by a crew and no quantity results, One "Quantity Placed" entry per crew containing the value of zero (0) is required

5.5. Gathering Data from *SiteManager*

VDOT provided access to the *SiteManager* software and data. The data was gathered from *SiteManager* by viewing the project diary history, the work item report, and the installed work report. The diary history is a summarized list of the work items entered into *SiteManager*. This list cannot be exported from *SiteManager* or printed. The work item report presented every entry made for a selected work item and the installed work report presented all the entries made for the present estimate period. The work item report was used to view all the entries made for a selected DBI and the installed work report was used on a month to month basis to collect data for the present estimate period. The data was copied from these reports to be used for the statistical analysis.

5.6. Summary

The designed field study was implemented. Two projects were selected in the Staunton District to collect data manually and with *SiteManager* after the methods of use were modified. Four projects were selected in the Salem district to collect data manually

and with *SiteManager* with no modifications. The data collection procedures were introduced to the project personnel and they began collecting data. The performance data was gathered from *SiteManager* using the diary history, item work report, and installed work report. It was copied from these means to perform a statistical analysis.

Chapter 6: Feasibility Analysis of *SiteManager*

6.1. Introduction

This feasibility analysis looked at *SiteManager* to determine if it was possible to use it to collect the data and a practical way of collecting the data. *SiteManager* was then evaluated to ensure it has the capability of collecting performance data and provides a logical method of collecting performance data. This can be done by either modifying the methods of *SiteManager* use or the *SiteManager* system. Both of these options are evaluated and the results are discussed.

6.2. Feasibility Criteria

The *SiteManager* software was designed for construction inspectors to use to document the construction process, administer a contract, and initiate payments to the contractor. It was not designed for collecting performance data. For this use *SiteManager* must be able to:

1. Collect performance data for activities

2. Collect the daily quantity of work placed for the activity

3. Collect the number of days work was performed on each activity

4. Collect the number of crews per day which worked on each activity

5. Export all data collected

If *SiteManager* did not have all of these capabilities, it could not be considered a feasible option for collecting performance data.

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6.2.1 Collecting Data for Activities

The Partnership defined eight project types to characterize VDOT construction projects. Common activities were defined for each of these eight project types. *SiteManager* does not have the capability of listing these activities or tracking the performance of these activities. It does, however, define bid items and track the quantity placed for each bid item. *SiteManager* has this capability to initiate payment to a contractor. For this reason, driving bid items (DBIs) were introduced, defined, and associated with the list of common activities for each project type.

By collecting the quantity of work for each DBI, the time required to install the quantity, and the number of crews utilized per day on each DBI, performance data will be collected for the activity the DBI is associated with. Because DBIs were introduced and performance data will be collected for each DBI which is associated with an activity, *SiteManager* has the capability of collecting data for activities.

6.2.2 Collecting the Quantity of Work

SiteManager was designed with the capability of collecting the quantity of work placed for each bid item. In order to pay a contractor, the number of units placed for each bid item is tracked in *SiteManager* and through the monthly estimate, the contractor is paid. For this reason, the existing system and methods are adequate for the requirements of collecting performance data.

6.2.3 Collecting the Number of Days Performed

SiteManager was not designed to collect the number of days required to place each quantity recorded for each DBI. This is a vital piece of performance data. In order to collect this piece of data, modifications to either the way inspectors were currently using *SiteManager* or the *SiteManager* system needed to be made.

If modifications were made to the *SiteManager* methods of use, these modifications would involve entering a quantity equal to:

1. Zero, if work was performed on a DBI and no quantity resulted

2. The installed quantity, if work was performed on a DBI resulting in an installed quantity

In this way, each time an entry was made one day of time was allotted towards the activity. The count of the entries would be equal to the number of days required to perform an activity and the sum of the quantity would be equal to the total quantity of work placed for an activity. This would give *SiteManager* the capability to collect the number of days required to perform an activity.

With this method there are situations which can occur to produce an inaccurate representation of actual conditions. Special care must be taken to ensure the number of entries equals the number of crew days performed and the sum of the quantity installed is correct. The following situations, however, may result in data collection issues:

1. It is standard practice to enter the percent complete for lump sum items on the day the estimate is being performed. This may not be a day the contractor worked on the DBI. By entering the percentage complete quantity on a day

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the contractor did not work, the number of quantity entries will not correspond with the number of crew days.

2. There are times when an inspector may choose not to enter a quantity for payment to the contractor until a later date even though the contractor has placed a quantity. One example could be a failure by the contractor to place the quantity with full adherence to the specifications causing the inspector to withhold payment until there is full adherence to the specifications. The inspector may then enter the quantity on a date when no work was performed on the activity. This will cause the total quantity installed to be correct but it will cause the number of quantity entries not to correspond with the number of crew days. This will produce inaccurate results.

3. If the inspector enters quantities for a DBI on a day when no work was performed to adjust the quantities to a correct value, the number of quantity entries will not correspond with the number of crew days. This will cause an extra day to be attributed to the performance of that DBI.

If modifications were made to the *SiteManager* system, these modifications need to separate the method for accounting time and the method for accounting installed quantity. This would eliminate the data collection issues discussed above. This can be accomplished by creating a binary indicator for each DBI. When the binary indicator is checked, work is being performed on the DBI. This would be case whether a quantity was entered or not.

6.2.4 Collecting the Number of Crews

In order to more accurately collect the time required to place a quantity which represents actual field situations, the time component of performance data needed to have units crew days. This requires the number of crews utilized each day during the performance of an activity to be collected. This was a capability which *SiteManager* did not currently have without making a modification either to the *SiteManager* methods of use or the *SiteManager* system.

If modifications are made, there were several different ways the number of crews could be collected:

1. Assume the number of crews equal the number of supervisors

    a. Method: Information regarding the number of superintendents and number of supervisors is collected daily by assuming that one supervisor is present for every crew. One could then determine the number of crews present for each day.

    b. Problem With Method: There is no link between the crews and activities. On cannot determine which activities each crew worked on. If there were a greater number of crews than activities, it would not be known which activity to attribute the extra crews. This would cause the number of crews to be divided by the number of activities to allocate the crews to the activities.

2. Non-Standard Bid Items for Crews

a. Method: A non-standard bid item could be added for each DBI. The quantity entered for each day on the non-standard bid item could be equal to the amount of crews working on the DBI.

b. Problem With Method: The non-standard bid items would cause confusion for the inspectors tracking the number of crews and the VDOT personnel required to audit the construction documentation. The data would also appear on project estimates for contractor payment, but the contractor would receive $0/unit for each of these items. The method would require inspectors to make two bid item entries for each work item.

3. Using Other Available *SiteManager* Fields

a. Method: There are other fields which are available within *SiteManager* which are sometimes unused. An example of such a field is the "Plan Page Number" field. This field is intended to identify the page number within the plans associated with the work. This field, however, is rarely used and could be used to record the number of crews.

b. Problem With Method: These fields are intended for other purposes and, although rare, are sometimes used for those purposes. Therefore, it is not consistently available for use.

4. One Bid Item Entry for Every Crew

a. Method: Each time work is performed on a DBI with more than one crew, one entry can be made for each crew.

b. Problem With Method: This method requires some extra work for the project inspector to make one entry for each crew, as opposed to one entry for each DBI on which work was performed.

5. Create a New Field

a. Method: a new field could be created for each DBI titled, "Number of Crews." This would require the inspector to enter the number of crews required to place the quantity for each entry.

b. Problem With Method: This method will require a modification to the *SiteManager* System which may not be possible.

Each of the above methods would provide *SiteManager* the ability to collect the number of crews. If there is no desire to make modifications to the *SiteManager* system, the number of crews should be collected by making a work item entry for each crew. However, the most practical way to collect this information would be to separate the method of collecting crews and the method of collecting quantity and make a modification to the *SiteManager* system by adding a field titled "Number of Crews." This would decrease the confusion inspectors may have regarding making additional entries and it would reduce the amount of time required to enter the data which would reduce the work load.

6.2.5 Extracting Performance Data From *SiteManager*

SiteManager not only needed to be a feasible option for collecting performance data, but also it needed to be a feasible option for extracting data. This process needed to be as automated as possible to eliminate VDOT personnel from extracting the data from

SiteManager and re-entering it into BIDDS. Eliminating double entry would decrease the work load required to facilitate the process of transferring the data from *SiteManager* to BIDDS and it will also eliminate errors caused by re-entering data into BIDDS.

Data could be collected from *SiteManager* under two different circumstances, making modifications to the way in which *SiteManager* is used and making modifications to the *SiteManager* system. Both these circumstances necessitate a different report to be generated and exported from *SiteManager*.

1. Making Modifications to the Way *SiteManager* is Used

   a. Using this method, quantity is collected by entering the resulting daily quantity in *SiteManager* for each DBI. The number of crew days are collected by making an entry into *SiteManager* for each crew which worked on a DBI for each day. Using this method an inspector must keep track of the sum of the quantities and the count of the entries. The sum of the quantities must equal to total quantity installed to day for each DBI and the count of the entries must equal the total amount of crew days performed to date.

   b. The report needed to contain all the performance data required by BIDDS. This included the state project number, the bid item numbers, a date to specify the month and year the work was performed, and the information in each entry made in *SiteManager*. The total quantity for the month would be equal to the sum of the quantities for each month and the total number of days performed for the month would be the the number of entries for the month.

c. The installed work report was identified to contain all the required information. However, this report contains only information for the present estimate period. It does not contain any information from previous estimate periods. This report can be generated at any time during the estimate period, but it will only contain data which was entered between the last estimate and the moment the report was generated. It is standard practice for a project inspector to make entries for lump sum items just prior to generating a project estimate. For this reason, there is a small time frame during which this report can be generated when it will contain all of the necessary information. If it is generated prior to all the entries being made for the estimate period, inaccuracies will occur. This is one disadvantage to using this report. This report can be exported from *SiteManager* as a tab delimited text file. BIDDS does require that the data on the report be reformatted before it is imported into BIDDS.

d. A modification can be made to the *SiteManager* system to eliminate the disadvantage of using the installed work report and provide a much larger time frame to retrieve the data. A new report can be written which contains all the necessary information and can be generated at any time containing information for any time period.

2. Making Modifications to the *SiteManager* System

a. Using this method, quantity is collected by entering the resulting daily quantity in *SiteManager* for each DBI. The number of crew days is

collected through two separate actions. A binary indicator is used to specify if work has been performed on a DBI. If the binary indicator is turned on, work has been performed on the DBI. A created field is used to collect the number of crews utilized to perform the work on the DBI. For Example, if the binary indicator is turned on and two has been entered as the number of crews, two crew days are allocated towards the DBI for the performance day.

b. The same data is required by BIDDS no matter what method is used to collect the data. This data is the state project number, bid item number, month performed, year performed, monthly quantity, and number of days performed. There are reports within *SiteManager* which contain the state project number, bid item number, dates to calculate the month and year performed, and the monthly quantity. There, however, was not a report which contained the data collected from the binary indicator and the "Number of Crews" field which were created. For this reason, a new report would have to be created to contain this information. This report could be exported as a tab delimited text file and could even possibly be formatted with the requirements to import the file into BIDDS.

6.3. Feasibility of Training Inspectors to Collect Performance Data

In order for inspectors to collect performance data, training was required. Inspectors already know how to operate *SiteManager* to document the construction

process, administer the contract, and initiate the payment process. Different training regarding the modification to *SiteManager* would be required depending on whether modifications were made to the methods of use or the system.

6.3.1 Inspectors' Current Use of *SiteManager*

Inspectors currently use *SiteManager* to document the construction process by recording comments describing the events of the day. Additionally, the number of superintendents, number of supervisors, and number and classification of the workers are recorded by the inspectors. Each piece of equipment and its type are also recorded.

To track quantities for payment, the inspectors enter the resulting daily quantity for each bid item. The inspector has to ensure that the sum of the quantity for each bid item was equal to the total quantity installed to date. This is done with little concern as to the number of entries required to maintain the accurate sum of the quantity.

6.3.2 Inspector Training on Modifications to the Way *SiteManager* is Used

In order for inspectors to collect data by changing the way *SiteManager* is used, training was required. Instead of simply entering the resulting daily quantity and maintaining an accurate sum of the total quantity regardless of the number of entries required, the inspectors would now have to also maintain an accurate count of the number of entries required enter the total quantity. This was because the number of entries was equal the number of crew days and any additional entries would cause this data to be inaccurate.

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This process was done by meeting with the project inspectors and explaining the process of collecting performance data by changing the use of *SiteManager*. A training guide was developed to explain this process of collecting performance data and can be found in Appendix D.

6.3.3 Inspector Training on Modifications to the *SiteManager* System

If modifications were made to the *SiteManager* system, some training would also be required for the project inspectors. This training would not require inspectors to make any modifications to the way in which they currently use *SiteManager*. For this reason, it would most likely be easier for the inspectors to understand the concepts presented in this training as opposed to the concepts presented in the training on changing the way *SiteManager* is used.

Using this method of collecting performance data inspectors need only to enter the resulting daily quantity and maintain an accurate sum of the total quantity regardless of the number of entries required. Separate fields are used to collect the number of days performed and number of crews utilized. Training of this nature needs to address the following points:

1. Performance data includes the collection of the quantity of work performed for an activity, the amount of time required to perform the quantity of work, and the number of crews utilized during the performance of that work.

2. Performance data will be collected for driving bid items. These are bid items which drive the work for the respective activities with which they are associated.

3. No modifications will be made to the way in which *SiteManager* is used to collect the quantity of work performed for a DBI. This information is already collected in an appropriate manner when the resulting daily quantity is entered into *SiteManager* to initiate the payment process.

4. In order to specify when the contractor has worked on a DBI, the binary indicator is used. When a contractor is working on a DBI, the binary indicator needs to be turned on. When no work is being performed on a DBI, the binary indicator needs to remain off.

5. To collect the number of crews utilized on a activity, the number of crews field is used. When work has been performed on an activity and the binary indicator has been turned on, the inspector can specify how many crews were used to perform the work on this DBI.

6.4. *SiteManager* Feasibility Overview

SiteManager was found to be a feasible option for collecting performance data. It has the capability to collect the performance data and is a reasonable method to use to collect performance data. Modifications can be made to the *SiteManager* system, however, to provide greater ease of use when collecting performance data, solve potential data collection issues, give *SiteManager* additional capabilities, and cause this method of data collection to become a more logical method of collecting data. Table 6.1 provides an overview of the feasibility of *SiteManager*. It contrasts changing only the methods inspectors use *SiteManager* to changing the *SiteManager* System.

Table 6.1: Overview of *SiteManager* Feasibility

Required Capabilities		Data Collection Methods	
		Changing Method of Using SiteManager	Changing SiteManager System
Specifying Activities		Use Driving Bid Items	Use Driving Bid Items
Collecting Quantity		Inspectors enter the resulting daily quantity as normal	Inspectors enter the resulting daily quantity as normal
Collecting Number of Days Performed	Method	Daily specify DBIs worked on by making a quantity entry for each one	Daily specify DBIs worked on by turning on binary indicator
	Potential Problems	Additional entries will be counted as a day work was performed on a DBI, Inspector must consider the sum of the quantity and the sum of the entries, May cause questioning by auditors	No known issues
	Recommendation	This method will collect production data but is not the recommended method	This method is recommended because there are less chances for errors, greater ease of use, and more comprehendible by inspectors
Collecting Number of Crews	Method	Make one entry per crew for each DBI for each day	Specify the number of crews per DBI for each day in the number of crews filed
	Issues	Additional entries will be counted as an extra crew working on the particular day, Inspectors must consider the sum of the quantity and the sum of the entries, May cause questioning by auditors	No known issues
	Recommendation	This method will collect production data but is not the recommended method	This method is recommended because there are less chances for errors, greater ease of use, and more comprehendible by inspectors

6.5. Recommendations

It is recommended that *SiteManager* be used to collect performance data. In order for it to be used, modifications are required to either the methods of use or to the *SiteManager* system. If modifications are made to the methods of use, it is recommended that crew days and quantity be collected by entering the resulting daily quantity for each crew, even if this quantity is zero. If modifications are made to the system, it is recommended that quantity be collected by using the current methods, time be collected through the use of a binary indicator for each DBI, and number of crews be collected through the use of a new field titled, "Number of Crews."

Chapter 7: Accuracy Analysis of Performance Data

7.1. Introduction

One of the three criteria specified in the objectives of this research was the data needed to be reasonably accurate. In order to accomplish this, a statistical analysis was required. This statistical analysis had three purposes:

1. Determine if the data VDOT was currently gathering with *SiteManager* was reasonably accurate for use in calculating the average daily crew output (ADCO).

2. Determine if the data collected from *SiteManager*, after modifications were made to the methods of use, was reasonably accurate for use in calculating the ADCO.

3. Determine which method of data collection produces the most accurate means of collecting performance data.

It was the hypothesis that modifications were required to the way *SiteManager* was used in order to collect data to produce more accurate data and when no modifications were made, the data would not be reasonably accurate.

7.2. Collected Performance Data

Data was collected on each of the two projects located in the Staunton District and the four projects located in the Salem District. Two different data collection methods were used. The difference between the two data collection methods was the way in

which *SiteManager* was used to collect the performance data. These two data collection methods are:

1. Type I collection method was used on the projects in the Staunton District. Type I data was collected using both *SiteManager* with modifications made to the methods of use. These modifications included daily recording the resulting daily quantity installed for each DBI, even if this quantity was zero. Each entry attributed one day of time towards the DBI.

2. Type II collection method was used on the projects in the Salem District. Type II data was collected using *SiteManager* with no modifications made to the way in which *SiteManager* was used. The inspectors used *SiteManager* in the same way they would have used it on any other project.

In addition to collecting data using one of the two data collection methods, all projects collected data manually through the use of data collection forms. The inspectors would manually record on the data collection form the resulting daily quantity installed, even if the quantity equaled zero. The statistical analysis was based on the assumption that the data collected manually was accurate data. This assumption was made because the inspectors were on the projects, recorded the data daily, the data should be free of typing mistakes, the data would not be altered by computer software. This data was considered to be the control data.

7.3. Statistical Analysis

After the data was collected, Type I and Type II data were compiled into two sample distributions each. For both types of projects, there was one sample distribution

containing ADCOs calculated for DBIs from *SiteManager* data and one distribution calculated from data collected manually. A Wilcoxon rank sum test was used to test the hypothesis that the two samples came from the same population.

7.3.1 Test Type I Data

This analysis followed the steps as presented in section 2.6. Statistical Analysis: Wilcoxon Rank Sum Test of this document.

1. The two samples of data were organized where the number of observations in sample 1 was less than the number of observations in sample 2 as can be seen in Table 7.1. It was originally expected that the two sample sizes would have the same sample size and should include the exact same data collected from two different collection methods. The only explanation for the two sample sizes differing is that there were errors in recording the manually collected data. Sample 1 was weekly ADCOs calculated from data collected with the manual method and sample 2 was weekly ADCOs calculated from data collected with *SiteManager*.

2. Both Samples were combined

3. The data values were ordered from smallest to largest as can be seen in Appendix E.

4. Ranks were assigned from 1 to N for each of the data values with 1 corresponding to the smallest value and N corresponding to the largest value. N = 129.5.

5. When there were two data values in the combined set of data which was duplicated, the average of the ranks for the duplicated observations was assigned as the rank for the duplicated observations.

6. The sample sizes were large because both n_1 and n_2 were greater than 10.

7. Table 2.2 was used to calculate the following results:

H_o: The two populations are identical. The confidence interval, $\alpha = 0.5$

H_a: Populations 1 and 2 are shifted from each other and are not identical. This alternative hypothesis was chosen because it is not expected that the distribution from Type I data collected with *SiteManager* will be shifted either to right or to the left of the distribution from the data collected manually.

Rejection Region: Reject H_o if $|z| \geq z_{\alpha/2} = z_{0.975} = 1.96$ (Ott 2001)

Calculations: $T = 4230.5$, $n_1 = 64$, $n_2 = 66$

$$\mu_T = \frac{64(64+66+1)}{2} = 4192$$

$$\sigma_T^2 = \frac{64*66}{12}\left((64+66+1) - \frac{130518}{(64+66)(64+66-1)}\right) = 43{,}372.45$$

$$z = \frac{4230.5 - 4192}{\sqrt{43372.45}} = 0.185$$

Since $z = 0.185 < z_{\alpha/2} = 1.96$, accept H_o that the populations are identical and conclude that that Type I data collected with *SiteManager* is not statistically different than that collected manually.

Table 7.1:Weekly Average Daily Crew Outputs From Type I Projects

Manual	SM	Manual	SM
X1i	X2i	X1i	X2i
0.00	0.00	1.00	1.00
0.00	0.00	1.00	1.00
0.50	0.50	1.00	1.00
0.25	0.50	0.00	0.00
0.00	0.00	0.00	0.00
21.50	21.50	0.00	0.00
0.00	0.00	0.00	0.00
0.00	0.00	3.00	5.80
0.00	0.00	4.73	4.73
18.00	18.00	0.00	0.00
5.50	5.50	0.00	0.00
15.50	15.50	1.00	1.50
8.00	8.00	1.00	1.00
23.00	23.00	0.00	0.00
40.00	40.00	0.00	0.00
8.00	8.00	32.26	32.26
16.00	16.00	0.00	0.00
43.00	43.00	0.00	0.00
56.00	56.00	0.00	0.00
30.00	30.00	6.00	6.00
0.00	0.00	45.50	45.50
13.33	13.33	1.00	1.00
26.55	19.55	0.05	0.05
13.50	13.50	0.10	0.00
10.00	10.00	0.00	0.20
12.00	21.33	0.00	0.00
8.00	8.00	0.00	0.00
18.67	18.67	0.10	0.00
8.00	8.00	0.00	0.00
0.00	0.00	0.00	0.20
1.00	1.00	14.00	0.00
1.00	1.00		0.10
1.00	1.00		0

Count of Sample 1 = 64
Count of Sample 2 = 66

7.3.2 Test Type II Data

This analysis followed the steps as presented in section 2.6. Statistical Analysis: Wilcoxon Rank Sum Test of this document.

1. The two samples of data were organized where the number of observations in sample 1 was less than the number of observations in sample 2 as can be seen in Table 7.2. Sample 1 was weekly ADCOs calculated from data collected with *SiteManager* and sample 2 was weekly ADCOs calculated from data collected manually. This was as expected,

2. Both Samples were combined

3. The data values were ordered from smallest to largest as can be seen in Appendix F.

4. Ranks were assigned from 1 to N for each of the data values with 1 corresponding to the smallest value and N corresponding to the largest value. $N = 197$

5. When there were two data values in the combined set of data which were duplicated, the average of the ranks for the duplicated observations was assigned as the rank for the duplicated observations.

6. The sample sizes were large because both n_1 and n_2 were greater than 10.

7. Table 2.2 was used to calculate the following results:

H_o: The two populations are identical. The confidence interval, $\alpha = 0.5$

85

H_a: Population 1 is shifted to the right of population 2. This alternative hypothesis was chosen because it is expected Type II data collected with *SiteManager* will have distribution shifted to the right of data collected manually. This was expected because the data collected with *SiteManager* did not include the zero entries used to record time spent working on a bid item when no quantity resulted and the data collected manually did include these zero records. This would cause the ADCOs collected from *SiteManager* to be greater in value than the ADCOs collected manually.

Rejection Region: Reject H_o if $z \geq z_\alpha = z_{0.95} = 1.945$ (Ott 2001)

Calculations: $T = 9815$, $n_1 = 80$, $n_2 = 117$

$$\mu_T = \frac{80(80 + 117 + 1)}{2} = 7920$$

$$\sigma_T^2 = \frac{80 * 117}{12}\left((80 + 117 + 1) - \frac{74244}{(80 + 117)(80 + 117 - 1)}\right) = 152940.2$$

$$z = \frac{9815 - 7920}{\sqrt{152940.2}} = 4.85$$

Since $z = 4.85 > z_\alpha = 1.945$, reject H_o that the two populations are identical and conclude that that Type II data collected with *SiteManager* is statistically different than that collected manually.

7.4. Discussion of Results

The results from the test on the Type I projects led to the conclusion that the data collected from *SiteManager* was not statistically different than that collected manually, even though there were errors in collecting the manually collected data. Additionally, the results from the test on Type II projects led to the conclusion that the data collected from *SiteManager* was statistically different than that collected manually. Based on these conclusions, it can also be concluded that data from *SiteManager* with modifications made to the methods of use is reasonably accurate for calculating ADCOs and the data collected from *SiteManager* when no modifications were made is not reasonably accurate for calculating ADCOs. Therefore, the data collection method which produces the most accurate data is *SiteManager* with modifications made to the methods of use.

7.5. Recommendations

It was concluded that the current use of *SiteManager* will not produce accurate performance data. In order to obtain accurate performance data, it is recommended that modifications be made to *SiteManager*. These modifications can be to either to methods of *SiteManager* use or to the *SiteManager* system.

Table 7.2: Weekly Average Daily Crew Outputs from Type II Projects

SM	Manual	SM	Manual	SM	Manual
X1i	X2i	X1i	X2i	X1i	X2i
0.10	0.00	32.67	63.35	1.81	0.00
0.60	0.18	2.00	0.00	1.00	0.00
0.30	0.00	575.00	0.00		0.11
75.12	0.03	91.67	33.50		0.00
192.50	0.00	125.00	67.00		18.88
0.10	0.00	32.67	63.35		0.00
0.60	0.18	2.00	0.00		0.00
0.30	0.00	575.00	0.00		0.11
75.12	0.03	91.67	33.50		0.00
192.50	0.00	125.00	67.00		18.88
414.00	59.15	716.00	5.00		296.00
150.00	150.24	556.00	5.50		0.00
53.00	0.00	274.00	0.00		42.50
14.64	0.00	21.96	23.97		106.88
2.44	7.32	24.09	25.00		0.00
21.96	2.44	49.75	11.13		2.42
51.57	80.00	11.06	23.64		5.77
121.67	22.00	23.65	29.40		0.02
56.96	52.00	29.22	42.58		0.00
33.60	0.90	42.80	21.40		0.00
385.52	0.10	53.46	15.70		0.00
85.83	121.67	15.46	0.00		0.00
113.79	47.00	0.00	4326.50		0.55
152.83	303.34	175.00	907.00		0.00
65.92	101.48	9.41	470.00		0.00
18.11	18.11	24.00	355.00		0.00
31.12	0.00	21.79	180.00		0.15
134.40	31.20	9.00	10382.00		0.00
277.12	134.40	1.00	9.41		0.10
71.29	94.00	1.00	24.00		0.00
562.59	119.26	0.45	0.00		0.00
399.98	39.43	63.50	5.45		17.50
22.04	310.08	131.90	2.25		34.60
14.63	369.32	296.00	0.00		0.00
264.36	52.43	0.15	0.00		0.00
285.71	22.04	0.50	0.00		2.16
285.72	4575.00	17.50	0.00		0.00
63.35	39.53	34.60	0.00		0.91
67.00	94.34	3.25	0.00		1.00

Count of Sample 1 = 80
Count of Sample 2 = 117

Chapter 8: Technical Analysis of Performance Data

8.1. Introduction

The technical analysis was one of the three analysis performed on the performance data. This analysis involved ensuring the data exported from *SiteManager* could be converted into the format required for import into BIDDS. This was done by:

1. Reviewing the data requirements for BIDDS

2. Reviewing the data presented in the installed work report (IWR)

3. Identifying the process required to convert an Installed Work Report IWR into a file readable by BIDDS

4. Develop *SiteManager* Data Converter (SMDC) in the form of a Microsoft Excel macro to perform this process

5. Validating the results of the conversion.

8.2. Data Requirements for BIDDS

In order to produce accurate results within BIDDS, the database requires specific data. BIDDS requires both classifying data and performance data. The classifying data required by BIDDS includes the state project number, bid item number, month performed, and year performed. The performance data includes monthly quantity and number of crew days performed. BIDDS requires each one of these elements of data to have a specific format.

1. State Project Number: The user must ensure that the project number set up in BIDDS is the same project number used in *SiteManager*.

2. Bid Item Number: This number must be reported as a five digit number. This requires the bid item numbers which are less than 10000 to have leading zeros. For example a bid item number of 591 must be reported as 00591.

3. Month Performed and Year Performed: This must be the month and year which most closely represents the month in which the work being tracked was performed.

4. Monthly Quantity: This must be the sum of the quantity of work placed for each DBI during the month. All units of measurement must be standard units of measurement.

5. Number of Days Performed: This must be the sum of the number of crew days used to place the quantity of work.

Additionally, BIDDS requires the file to be a tab delimited text file with each row containing the data for a DBI. The format for this file can be seen in Table 8.1. The column headings in white will not be included in the import file but are included in the following table for reference.

Table 8.1: BIDDS Import File Format

Project Number	Bid Item Number	Month Performed	Year	Total Monthly Quantity	Total Number. of Crew Days
SD 0001	00100	9	2001	1	4
SD 0001	10630	10	2001	1022	1
SD 0001	68320	10	2001	78	1
SD 0001	68330	9	2001	31	1
SD 0001	10607	9	2001	59	1
SD 0001	54020	10	2001	2156	1
SD 0001	00100	11	2001	1	4
SD 0001	10630	10	2001	533	1

8.3. Data Presented in Installed Work Report

All of the data required to produce the BIDDS input file was contained in the IWR available in *SiteManager*. This report contained every entry made during the estimate period for the selected project. Each entry had a column containing the state project number, bid item number, date the entry was made, and quantity placed, as well as additional columns containing information not needed by BIDDS. Because this report contains only data for the current estimate period, the data is erased from the report when a project inspector generates a project estimate. This is because it becomes data from the previous estimate period. The data, however, remains within the *SiteManager* database.

It was initially anticipated the date associated with each entry would be used to determine the month performed and year performed. This, however, created a problem because the estimate calendar was not the same as the monthly calendar and most project estimates span a two month period. For example, project estimate number 1 in Figure 8.1 spans January and February, and Estimate number 2 spans February and March. By using the data to identify the month and year, two sums of data for each DBI would result from an IWR, one for each month in the two month span. Additionally, when multiple groups of data from an IWR is imported into BIDDS over a period of time, BIDDS will contain two sums of data for each DBI for each month.

Because of this problem, it was decided the user would directly specify the month performed and the year performed. The month performed and the year performed would be the month and year of the estimate ending date. By referring to Figure 8.1, the data collected during estimate number one would be reported with a month performed of February.
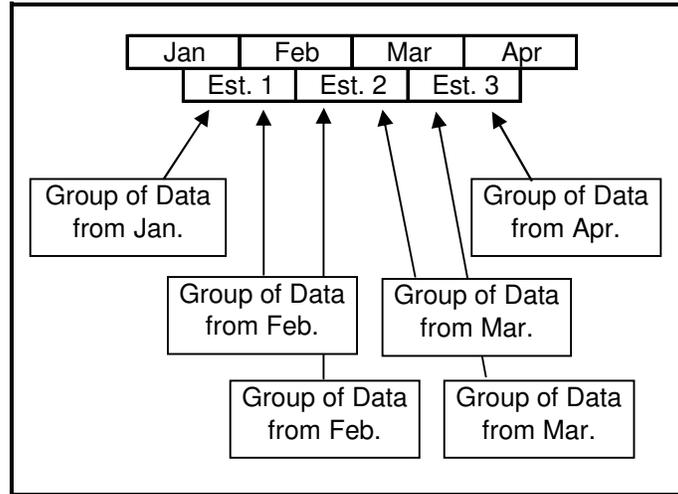
Figure 8.1: Month and Year Performed Problem

In this way the data reported as being performed in one month will actually have portions of work performed during the previous month and portions of the work performed during the reported month. In order to avoid this issue, a new report can be created which contains the classifying data and performance data required by BIDDS and can contain the data for one calendar month.

8.4. *SiteManager* Data Converter

SiteManager Data Converter (SMDC) was created in the form of a Microsoft Excel macro to convert the required data in the IWR to a file containing the data required by BIDDS in the form and format required by BIDDS. SMDC requires an IWR exported from *SiteManager*, the project type, the estimate month and estimate year, and the units of measurement used. It selects the list of DBIs for the identified project type. The sum

of the work item entries is equal to the number of days performed. The sum of the quantity installed for the month equals the monthly quantity. The project number, driving bid item number, month performed, year performed, monthly quantity, and number of days performed is then copied onto a row in a new file. The source code for SMDC can be found in Appendix G.

8.5. Construction of *SiteManager* Data Converter

Figure 8.2 depicts a flowchart of the SMDC structure. SMDC was divided into seven processes which will be discussed in the following sections.

1. User Interface and Input Data – the framework of the data input form which the user encounters upon opening SMDC and the data required to operate the program.

2. Supporting Sheets – the Microsoft Excel data sheets which support the SMDC processes.

3. Validation of Input Data – the process SMDC undergoes to ensure all the required data is present before commencing the conversion process.

4. Preparation of Worksheets – the process through which all required worksheets are prepared to begin the conversion process.

5. Data Conversion – the procedure followed to convert data from an IWR and place it into the new workbook.

6. On Open Events and Protection – Events which happen when SMDC is opened and the process followed to protect SMDC.

7. Help – a form with predefined questions a user can seek for help.
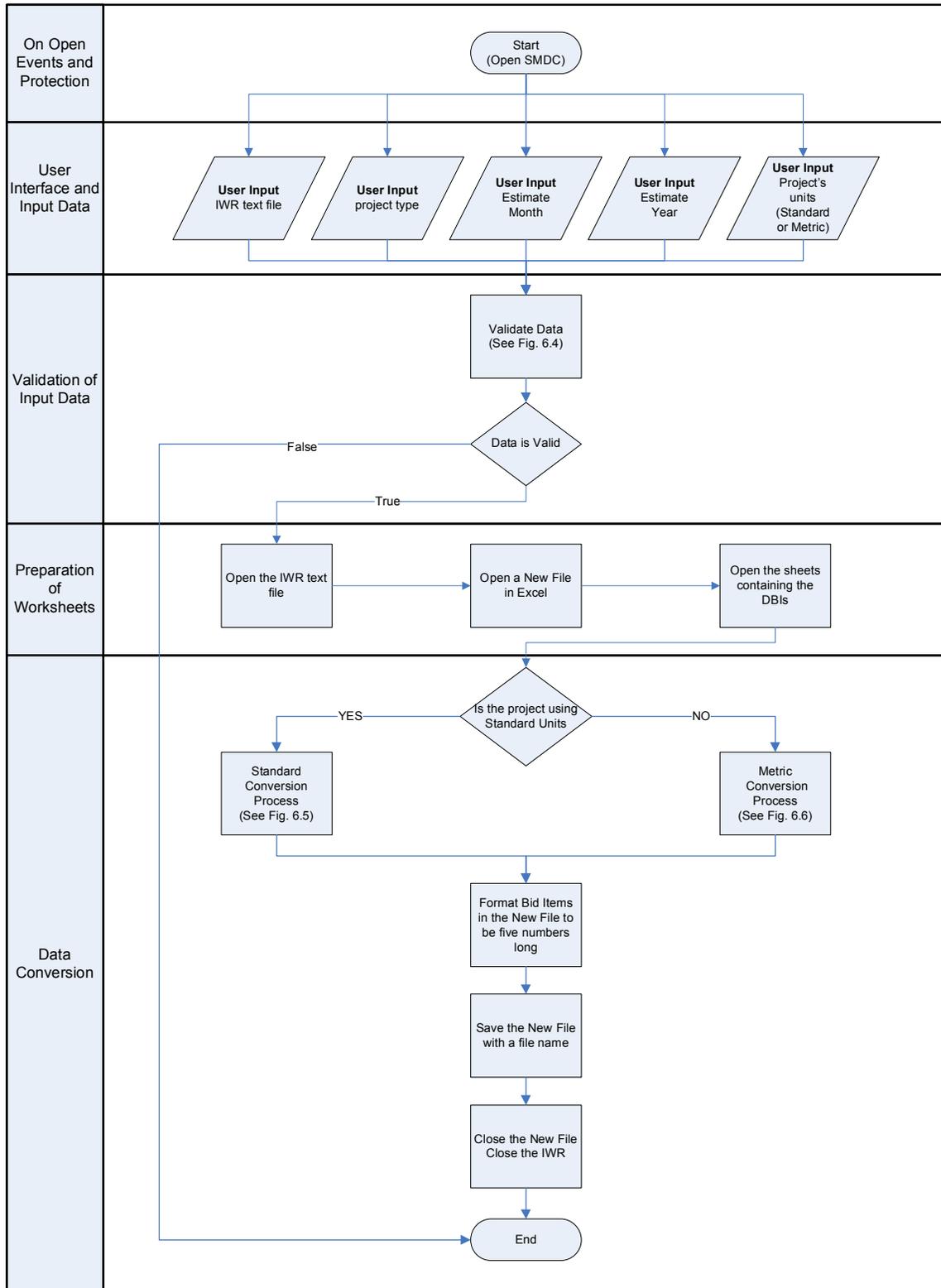
Figure 8.2: SMDC Flowchart

8.5.1 User Interface and Input Data

When the user first opens the *SiteManager* Data Converter file, they will encounter a user input form. This form is shown in Figure 8.3. This form allows the user to input the data required for SMDC to convert an IWR into a file readable by BIDDS.
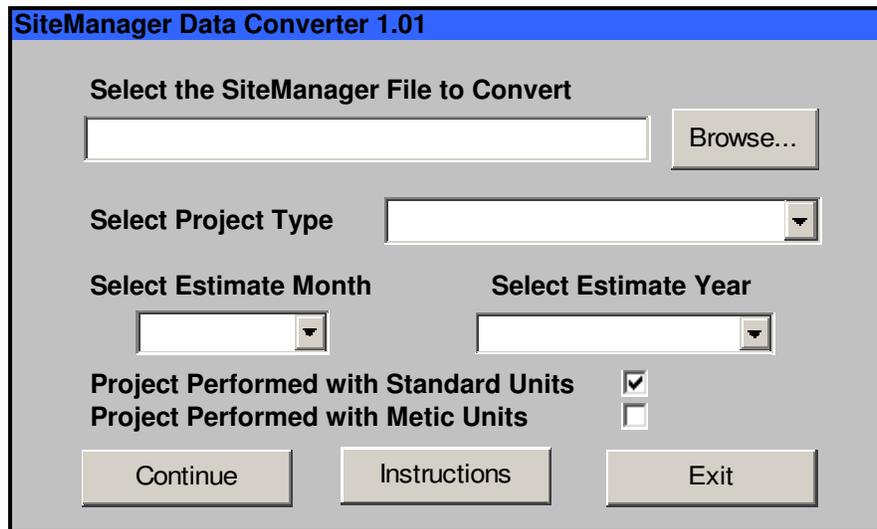
SiteManager Data Converter 1.01

Select the SiteManager File to Convert

[   ] [Browse...]

Select Project Type   [▼]

Select Estimate Month   Select Estimate Year
[▼]   [▼]

Project Performed with Standard Units   ☑
Project Performed with Metic Units   ☐

[Continue]   [Instructions]   [Exit]

Figure 8.3: *SiteManager* Data Converter User Form

The input process is explained below:

Browse Button – SMDC requires an IWR in a text file format. The browse button allows
 a user to input this text file with browse capabilities. When the Browse button is
 clicked an open file user form is initiated. The user is limited to selecting only
 text files. The user does have the ability to select text files which are not IWR
 text files. This user error may or may not be detected during the data validation
 process. If it is not detected during data validation, then the conversion process
 will continue and a new file will be created. The new file created would most
 likely not contain any information because no DBIs would be found in the
 selected text file and when the user tries to import this new file into BIDDS, there

will be no data added to the database. Once a file is selected and the user selects

open, the file name and extension will be displayed in the text box located to the

left of the Browse button.

Project Type Combo Box – a drop down list of project types. The project types available

to choose are New Road Construction, New Bridge Construction, Road

Reconstruction, Bridge Reconstruction, Road Rehabilitation, Bridge

Rehabilitation, Widening, and Overlay.

Estimate Month Combo Box – a drop down list of months.

Estimate Year Combo Box – a drop down list of years. The years range from 2005 to

2015.

Units Check Boxes – check boxes to select the units of measurement used for the project.

The file readable by BIDDS must always be in standard units. If metric units

check box is selected, the units will be converted from metric to standard.

8.5.2 Supporting Sheets

SMDC has a series of worksheets which contain data to support the processes.

There is one worksheet containing DBI information for each of the 8 project types. The

sheets containing DBI information appear as shown in Table 8.1. The worksheet

containing the DBIs for the selected project type is used to evaluate the bid items in the

IWR and determine if they are driving.

Table 8.2: Sample Project Type DBI information worksheet

NEW ROAD CONSTRUCTION				
Activity	**Bid Item No.**	**Description**	**Units**	**Metric Conversion Factor**
Mobilization	00100	MOBILIZATION	LS	1
Clearing & Grubbing	00110	CLEARING AND GRUBBING	LS	1
Remove Structures	70000	NS DEMO. OF BLDG.	LS	1
Roadway Excavation	00120	REGULAR EXCAVATION	CY	1.307951
Roadway Excavation	00128	EXTRA EXCAVATION	CY	1.307951
Roadway Excavation	00140	BORROW EXCAVATION	CY	1.307951
Grading	00125	GRADING	LS	1
Drain Pipes	00505	BEDDING MATL.AGGR.NO. 25 OR 26	TON	1.102311
Drain Pipes	01060	6" PIPE	LF	3.28084
Drain Pipes	01120	12" PIPE	LF	3.28084
Drain Pipes	01122	12" CONC. PIPE	LF	3.28084
Drain Pipes	01150	15" PIPE	LF	3.28084
Drain Pipes	01152	15" CONC. PIPE	LF	3.28084
Drain Pipes	01180	18" PIPE	LF	3.28084
Drain Pipes	01182	18" CONC. PIPE	LF	3.28084

8.5.3 Validation of Input Data

When the Continue button on the user form is clicked, the first process SMDC performs is validation of input data. As can be seen in Figure 8.4, this process checks to ensure all input data is present. It checks:

1. The browse text box to see if it contains a file name and extension.

2. Each of the three combo boxes (project type, estimate month, and estimate year) to ensure a selection has been made

If any of the input data is not present, a message box will appear stating no selection has been made.
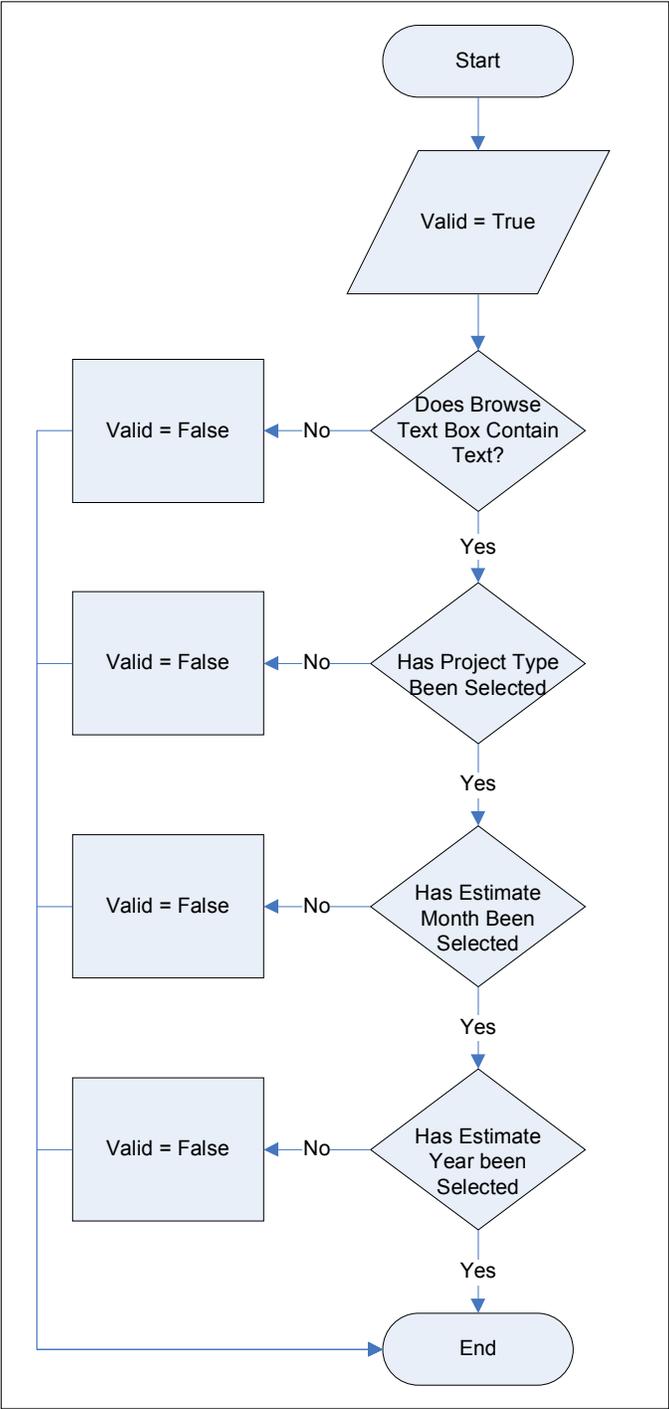
Figure 8.4: Validation of Input Data

8.5.4 Preparation of Worksheets

In order to prepare all the worksheets for the data conversion process, the IWR text file must be opened, a new file must be created to write new converted data, and the appropriate project type worksheet must be selected. These actions begin after valid data has been input into the user form.

SMDC opens the IWR file specified in the browse text box as a tab delimited text file in Microsoft Excel and a new file is created in Microsoft Excel where converted data readable by BIDDS will be written. In order to select the appropriate list of DBIs, the text in the project type combo box selection is matched to the name of the project type worksheets in SMDC. If "New Road Construction" is selected in the project type combo box, then the worksheet titled New Road Construction is used. The project type worksheet being used is then named DBISheet which stands for Driving Bid Item worksheet and the range containing all the bid item numbers and descriptions are selected and named DBI.

8.5.5 Data Conversion

The data conversion process is the most involved process of SMDC. It involves interaction between all three of the open files, SMDC, IWR, and the new file. Additionally, there is both a data conversion process when standard units are used and one for when metric units are used. These two processes are remarkably similar, but the metric data conversion process also converts metric units to standard units. A more detailed discussion of the mechanics of the Visual Basic for Applications code used to accomplish this process can be found in Appendix H.

1. Standard Data Conversion Process – Figure 8.5 is a flow chart demonstrating the standard data conversion process. This figure fits into Figure 8.2 as the process labeled Standard Data Conversion Process.

   This process begins by selecting the first row in the IWR and testing to see if there is any data in this row. When there is no data in this row, the conversion process ends because the IWR does not contain any data. If there is data in this row, SMDC sets the variable BI equal to the bid item number and SMQ equal to the quantity reported by this row.

   The bid item number, BI, is then checked to see if it is a DBI. If this number is not a DBI then SMDC will go to the next row and check if there is data. If this number is a DBI then SMDC begins writing classifying data and performance data onto a row in the new file. The project number and bid item number are copied from the IWR. The month and year performed were copied from the user entry. The number of days performed equals the count of all the rows with a bid item number equal to BI. The monthly quantity equals the sum of SMQ for each row with a bid item number equal to BI. After data is written to a row in the new file, SMDC will go to the next row and check if there is data.

2. Metric Data Conversion Process – the Metric data conversion process is the same as the standard data conversion process with one exception. When data is being recorded in the new file, the monthly quantity is converted from metric units to standard units. The metric conversion process is presented in Figure 8.6. This figure fits into Figure 8.2 as the process labeled Metric Data Conversion Process.
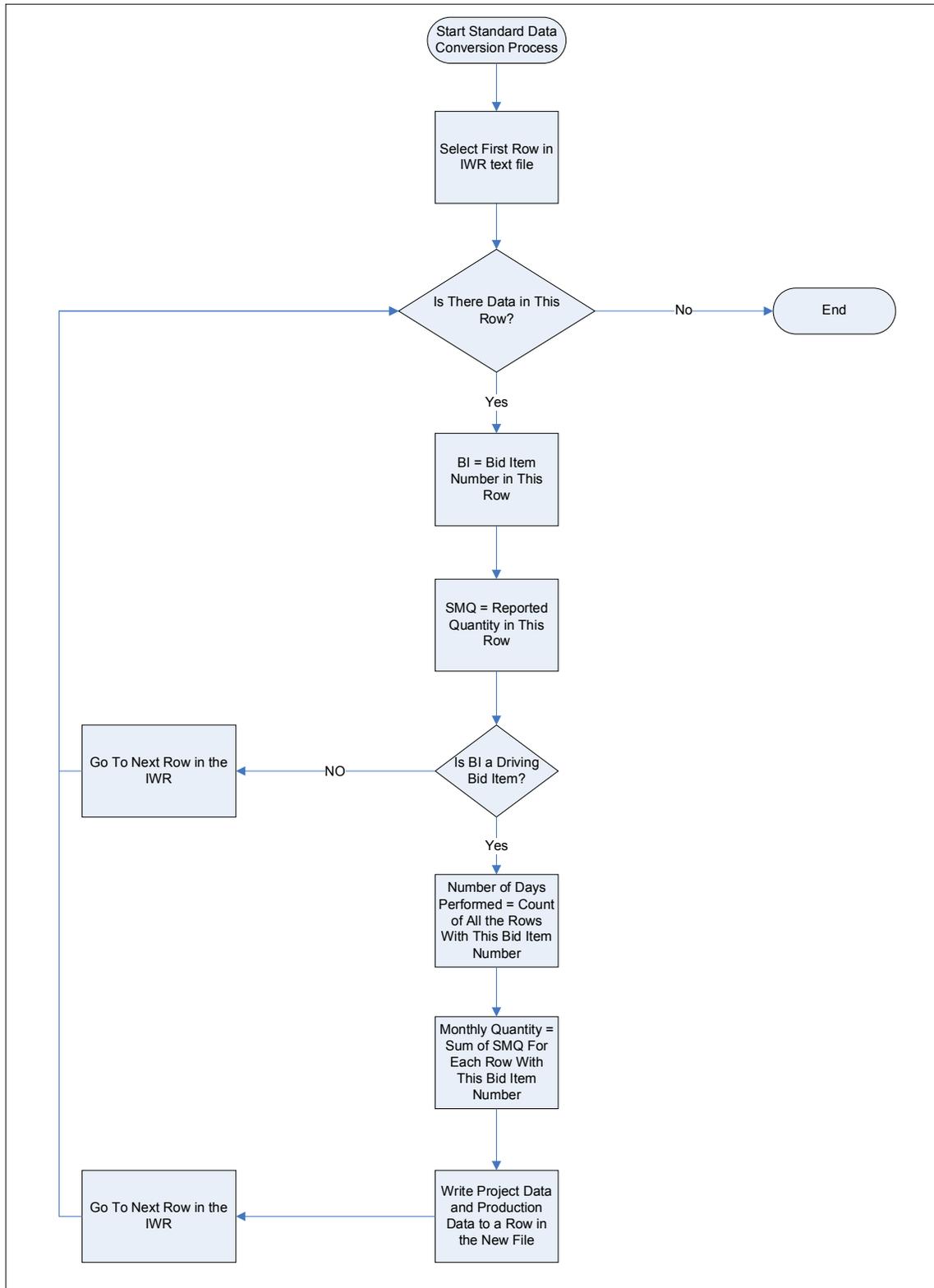
Figure 8.5: Standard Data Conversion Process
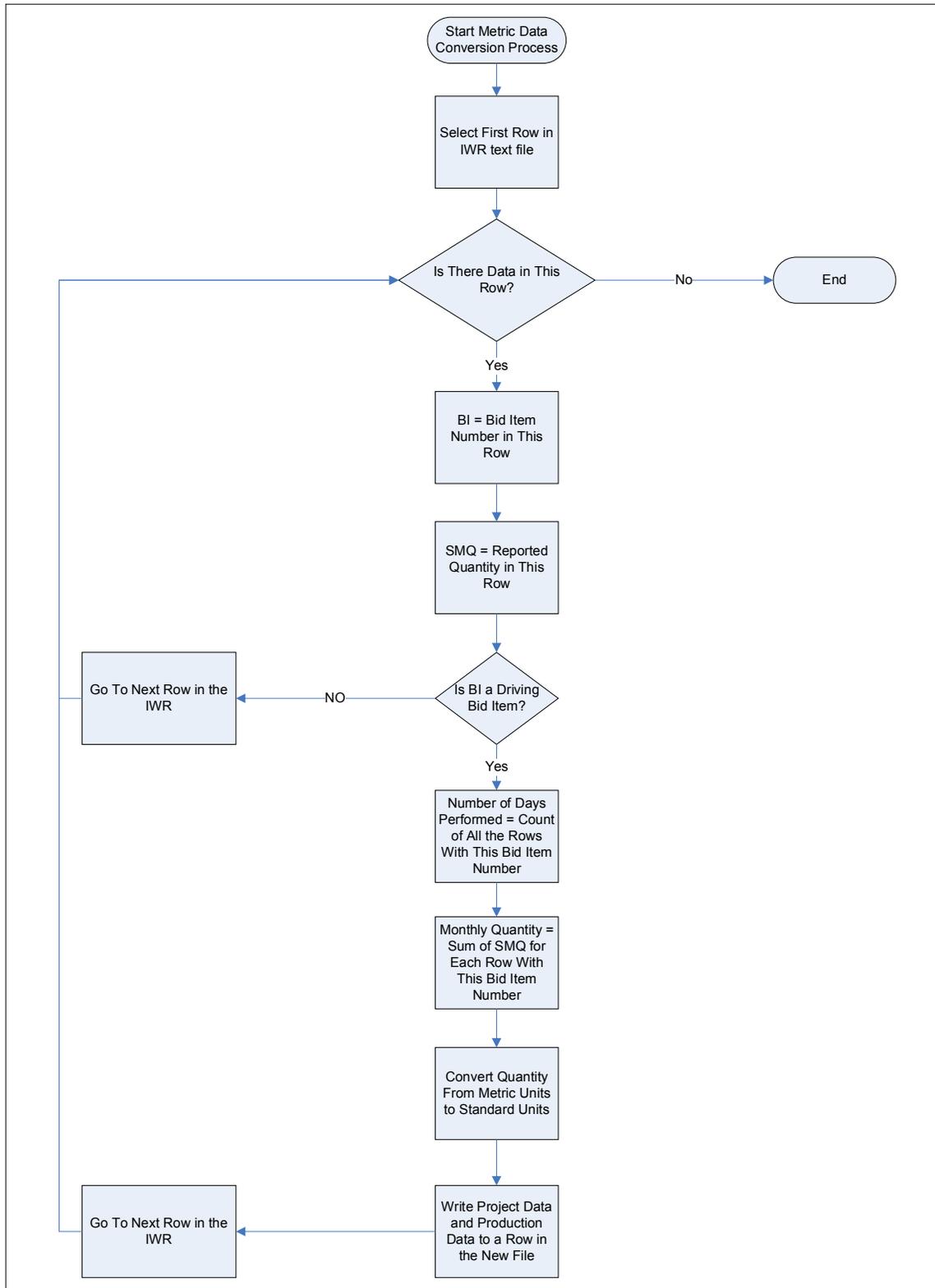
Figure 8.6: Metric Data Conversion Process

8.5.6 On Open Events and Protection

All of the worksheets which support the SMDC processes must be protected. If they were altered, it could be detrimental to SMDC and could cause inaccurate data to be transferred from the IWR to the new file being created. To accomplish this, the protection feature within Microsoft Excel was used to lock the cells in each of the project type worksheets, the Help worksheet, and the worksheet containing the user form. This does not allow any alterations to be made to these worksheets unless the worksheet is unprotected. To prevent unauthorized users from removing the protection on the worksheets and altering the information, the protection feature within Microsoft Excel was disabled. When the protection feature is disabled, the protection option on the tools menu is not available.

Further, there is no need for the user to see the supporting worksheets. For this reason, the project type worksheets and the help worksheet were hidden from the users. When the user opens SMDC, these worksheets will not appear to be available to the user.

An administrator, however, must have the ability to make modifications to SMDC, the DBIs, or the help contents. For this case, two macros were created to enable to protection feature within Microsoft Excel and show the hidden worksheets. The macros were named, EnableProtection and ShowWorksheets. When either of the macros are chosen to run, the user will be prompted for a password. Upon correctly entering the password for either the EnableProtection macro or ShowWorksheets macro, the macro would perform its function.

8.5.7 Help

The SMDC Help function allows the user to find detailed instructions associated with a list of predefined questions. The user can scroll through the list of predefined questions until he finds a question which most closely represents the problem encountered. Upon selecting this question, the answer to the question will be displayed. The help file contains eight questions and eight definitions of each of the eight project types. The help form appears as is shown in Figure 8.7. The contents of the help file can be found in Appendix I.
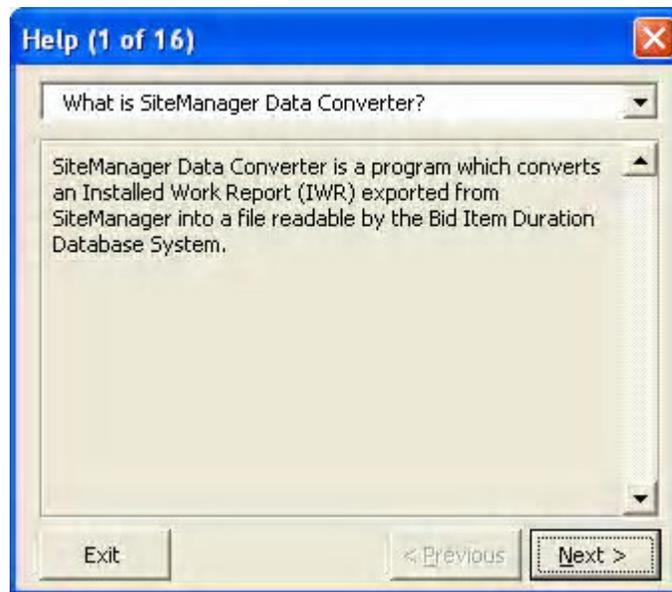
Figure 8.7: Help User Form

8.6. Verification of Results

In order to verify the results produced by SMDC, an IWR was exported from *SiteManager* to be converted. SMDC was used to convert this file and the appropriate project type, estimate month, estimate year, and units of measurement were selected. A

new file readable by BIDDS was created containing the data converted from the IWR. This file was then used to import into BIDDS. The project was initiated within BIDDS and the file was imported. The process was successful. This was done with both standard and metric units of measurement and by selecting different values for the estimate month and estimate year.

8.7. Limitations of SMDC

SMDC does have limitations. It is important for users to understand these limitations because they can greatly affect the output file which is readable by BIDDS. The limitations to SMDC are as follows:

1. SMDC is limited to converting only IWRs into text files readable by BIDDS. Any other reports generated from *SiteManager* which contain the required performance data cannot be converted by SMDC into a text file readable by BIDDS.

2. SMDC places the monthly sum of the time and quantity for each bid item into the text file readable by BIDDS. It does not place the daily performance data used to calculate the monthly sums into the text file readable by BIDDS.

3. SMDC will report only the month and year which the user specifies regardless of the dates on the entries associated with the data. The user must take care to enter the appropriate estimate month and estimate year.

4. SMDC will report only the DBIs for the project type selected. It will not report DBIs for other project types.

5. SMDC cannot differentiate between standard and metric units of measurement. BIDDS requires standard units of measurement and SMDC will convert metric

units in an IWR to standard units in the file readable by BIDDS. The user must take care to select the appropriate units of measurement.

6. SMDC produces an output file in the form and format required for BIDDS. This output file is not intended to be imported into any other database.

8.8. Conclusion

SiteManager Data Converter was constructed to convert the data in an IWR into a new file containing technical requirements specified by BIDDS. SMDC opens an IWR, counts the number of entries for each DBI, sums the quantity placed for each DBI, and copies this information to a new file as the number of days performed and monthly quantity. Classifying data such as the state project number and bid item number are also copied from the IWR into the new file. The month performed and year performed are entered by the user into SMDC and copied into the new file. The new file is created to meet all the technical requirements of BIDDS.

8.9. Recommendations

During the technical analysis, it was found that the IWR contains data from a two month span. When using the dates associated with each work item entry to determine the month performed and year performed, each IWR will have two groups of data, one group for each month in the two month span. This will cause BIDDS to contain two data points for each month of data.

To fix this problem, the user is required to directly input the month performed and year performed into SMDC. This is the month and year of the estimate ending date. This causes the reported month to contain portions of data from the previous month as well as the month being reported. To fix this issue it is recommended a new report be created which contains the classifying data and performance data required by BIDDS and contains data for a calendar month.

Chapter 9: Final Evaluation

9.1. Introduction

SiteManager was identified as the best available tool to use when collecting performance data for BIDDS. Because *SiteManager* is a construction documentation and accounting system, it needed to be assessed prior to use to determine data collection procedures required to obtain the performance time data specified by BIDDS and if any modifications to the methods of *SiteManager* use or the *SiteManager* system were needed. Both *SiteManager* and the performance time data it collected were assessed by the following three criteria:

1. *SiteManager* must be feasible to collect the required data

2. The data must be reasonably accurate

3. The data must meet technical requirements for import into BIDDS.

9.2. Feasibility Analysis

The feasibility analysis examined *SiteManager* to determine if it was capable of collecting performance data and if it was a practical method to use to collect performance time data. It was determined *SiteManager* is capable of collecting performance time data. It becomes capable when either the methods of *SiteManager* use or the *SiteManager* system are modified. Both of these options are valid possibilities for enabling *SiteManager* to collect performance time data and both have positive and

negative attributes. In order for *SiteManager* to collect performance time data, it needed to have the ability to:

1. Collect data for activities

    a. Driving bid items were defined and associated with activities.

    b. When modifying either the methods of *SiteManager* use or the *SiteManager* system, data is collected for activities by collecting data for DBIs.

2. Collect the quantity of work placed for the activity

    a. The methods used by project inspectors to enter an installed quantity was an acceptable method to use.

    b. No modifications were required. Inspectors need only to ensure the total quantity installed is correct.

3. Collect the number of days work was performed on each activity

    a. When modifying the methods of *SiteManager* use, the number of days work was performed on an activity is collected by requiring inspectors to make a work item quantity entry for each day work was performed on a DBI. The quantity of this entry would be equal to the resulting daily quantity, even if that quantity was zero.

        i. Additional work item entries made by inspectors for any reason will attribute a day of time to a DBI. This can cause errors.

        ii. Inspectors must ensure that the count of the entries equal the number of days work was performed on the DBI. This can become difficult because the method used to collect time and the method

used to collect quantity are not independent of each other. Inspectors cannot adjust the total quantity without making an entry.

    iii. Zero quantity entries show up on numerous reports. This can sometimes cause the report to be questioned and increase in length.

b. When changing the *SiteManager* system, the number of days work was performed on an activity is collected by requiring inspectors to turn on the binary indicator for the DBI.

    i. Additional work item entries made by inspectors will not attribute extra days of time to a DBI. This eliminates possible causes of errors.

    ii. Inspectors must ensure that both the total quantity is correct and the binary indicator is checked each day work is performed. These are independent of each other and any difficulties recording this data using the previous method are eliminated.

    iii. The binary indicator needs to be added to the *SiteManager* software.

4. Collect the number of crews utilized to perform work on each activity per each day work was performed on the activity

a. When changing the methods of *SiteManager* use, the number of crews used to perform work on a DBI is collected by requiring inspectors to make a work item quantity entry for each crew on each day work was performed on a DBI.

i. Additional work item entries made by inspectors for any reason will attribute a crew day of time to a DBI. This can cause errors.

ii. Inspectors must ensure that both the total quantity is correct and the count of the entries equal the number of crew days work was performed on the DBI. This can become difficult because inspectors cannot adjust the total quantity without making an entry.

iii. Zero quantity entries show up on numerous reports. This can cause the report to be questioned.

b. When changing the *SiteManager* system, the number of crews used to perform an activity is collected by requiring inspectors to record the number of crews used each day for a DBI in the field titled "Number of Crews".

i. Additional work item entries made by inspectors will not attribute extra days of time to a DBI. This eliminates possible causes of errors.

ii. Inspectors must ensure that the total quantity is correct, the sum of the days the binary indicator was turned on is correct, and the number of crews used to perform an activity each day is correct. These are independent of each other and any difficulties recording this data using the previous method are eliminated.

iii. The "Number of Crews" field needs to be created.

5. Extract all data collected

a. When changing the methods of *SiteManager* use, the data can be extracted by generating and exporting the installed work report.

b. When changing the *SiteManager* system, the data can be extracted by generating and exporting a new report created to contain performance data.

9.3. Statistical Analysis

Performance data was collected from existing VDOT projects using three different methods. Type I data was collected from projects which modified the way in which *SiteManager* was used. Type II data was collected from projects which did not make any modifications to *SiteManager*. The manual method required inspectors to record performance data by hand on a data collection form. All projects which collected either Type I data or Type II data also collected data using the manual method. Manually collected data was assumed to be accurate and was considered to be the control data for the statistical analysis.

Two statistical analyses were performed. In the first analysis, the average daily crew output calculated from Type I data was compared to the manually collected data from the same projects. This was done to determine if the data collected using *SiteManager* after the methods of use had been modified differed statistically from the manually collected control data. In the second analysis, the average daily crew output calculated from Type II data was compared with the manually collected data from the same projects. This was done to determine if the data collected from *SiteManager* after no modifications had been made differed statistically from the manually collected control

data.   After these two analyses were performed, the results were compared and conclusions were made.

The results from the first analysis led to the conclusion that Type I data did not differ statistically from the manually collected control data. The results from the second analysis led to the conclusion that Type II data did differ statistically from the manually collected control data.   These two conclusions further lead to the deduction that modifications were required to *SiteManager* in order to collect accurate performance data.

9.4. Technical Analysis

SMDC was created in the form of a Microsoft Excel macro to convert the data in an IWR to a file which meets the technical requirements specified by BIDDS. This was done by reviewing the data requirements for BIDDS, reviewing the data presented on the IWR, defining the process required to convert an IWR, and building SMDC.

SMDC requires the user to provide an IWR and specify the project type, estimate month and year, and units of measurement for the project. The project type selected specifies the list DBIs used to identify which bid items in the IWR are driving. For each DBI, the sum of the quantity installed for the month equals the monthly quantity, and the count of the number of work item entries for the DBI equals the number of crew days performed. This information is copied onto a row in the new file along with the project number, bid item number, and the estimate month and year.

9.5. Conclusion

In response to the research questions, it was found:

1. *SiteManager* cannot be used in its current format to gather the DIQ and ACD data required to populate BIDDS.

2. The data collected using *SiteManager* with modifications made to the methods of use agrees with performance data manually recorded by project personnel.

3. No modifications to the *SiteManager* system are required to provide the data necessary to populate the operations tier database. However, modifications are recommended to decrease data collection potential for errors, increase the accuracy of the data, and increase the ease of collecting performance data.

4. Modifications to the methods by which *SiteManager* is used are required to provide the data necessary to populate BIDDS. These modifications are as follows:

   a. Daily record a work item entry for each crew utilized to perform work on a DBI containing the resulting quantity installed by the crew.

   b. Daily record a zero quantity work item entry to track days work was performed by a crew on a DBI and no quantity was installed.

   c. Just prior to generating a project estimate, export an IWR from *SiteManager* and send it to the SMDC analyst.

Chapter 10: Recommendations

10.1. Introduction

During the progression of this research, several key issues pertaining to performance data collection were identified. These issues are critical to defining the methods used to collect performance data. A set of recommendations is offered for each issue. Some of the recommendations are required to ensure the capability of collecting performance data and some are optional. The optional recommendations are offered to solve issues with the data collection method but are not required to obtain performance data.

10.2. Recommendations

The issues and the recommendations to resolve the issues are presented below:

Issue I: A Source of Performance data is required

Recommendation 1.01: Use *SiteManager* to collect performance data. In order to have ability to collect accurate performance data, modifications must be made to *SiteManager*. These modifications will be discussed in the following recommendations.

    a) By implementing this recommendation project personnel will need to modify the way they use *SiteManager*.

    b) *SiteManager* does not have the ability to define activities. For this reason, performance data must be collected for bid items. The Partnership identified a

subset of bid items to be driving. These are the bid items used to collect

performance data.

Issue II: Distinguish Driving Bid Items

Recommendation 2.01: Modify the *SiteManager* system to distinguish the list of DBIs by

bolding the bid item text or filling the background with a different color.

     a) This method will clarify which bid items are considered to be driving.

     b) This method requires AASHTO to modify the *SiteManager* source code.

     c) This recommendation is optional. It will increase the ease of collecting

        performance data, but it is not required to obtain the necessary performance

        data.

Recommendation 2.02: Modify the *SiteManager* system to distinguish the list of DBIs by

adding a supplemental description to specify which bid items are driving.

     a) This method will identify the DBIs but will not be as obvious as the previous

        recommendation.

     b) This method requires VDOT to modify the *SiteManager* system.

     c) This recommendation is optional. It will increase the ease of collecting

        performance data but it is not required to obtain the necessary performance

        data.

Issue III: Collect Installed Quantity

Recommendation 3.01: Continue using the current methods to input the quantity installed

for each bid item.

Issue IV: Collect the Number of Days Work Was Performed on a DBI

Recommendation 4.01: Modify the methods of *SiteManager* use by requiring project personnel to record the resulting daily quantity for a DBI, even if the quantity is zero. Each entry made is counted as one day of work.

a) This method of tracking the number of days is not independent of the method used to track the quantity installed. Project personnel cannot adjust the total quantity without adjusting the time.

b) Zero quantity entries show up on numerous reports and may cause questions to be raised.

c) This method requires project personnel to modify the way they use *SiteManager*.

Recommendation 4.02: Modify the *SiteManager* system to include a binary indicator of when work is performed on a DBI.

a) This modification will require AASHTO to modify the *SiteManager* source code.

b) This method allows the method of tracking the number of days to be independent of the method used to track the quantity installed. Project personnel can adjust the total quantity without effecting the time.

c) This method eliminates questions resulting from zero quantity entries appearing on numerous reports.

It is required that one of the two methods presented to resolve this issue be implemented.

Issue V: Collect the number of crews utilized to perform the work on a DBI

Recommendation 5.01: Modify methods of *SiteManager* use by requiring project personnel to record the resulting daily quantity installed by each crew for a DBI even if the quantity is zero. Each entry is counted as one crew day.

   a) This method of tracking the number of crews per day is not independent of the method used to track the quantity installed. Project personnel cannot adjust the total quantity without adjusting the time.

   b) Zero quantity entries and multiple entries made per day show up on numerous reports and may cause questions to be raised.

   c) This method requires project personnel to modify the way they use *SiteManager*.

Recommendation 5.02: Modify the *SiteManager* system by including a field to record the number of crews per DBI.

   a) This modification will require AASHTO to modify the *SiteManager* source code.

   b) This method allows the method of tracking the number of crews per day to be independent of the method used to track the quantity installed. Project personnel can adjust the total quantity without effecting the number of crew days.

   c) This method eliminates questions resulting from zero quantity entries and multiple daily entries appearing on numerous reports.

It is required that one of the two methods presented to resolve this issue be used. Further, if Recommendation 4.01 is used, either Recommendation 5.01 or 5.02 can be used, but if Recommendation 4.02 is used, Recommendation 5.02 must also be used.

Issue VI: Export Performance Data

Recommendation 6.01: Export performance data by using the installed work report (IWR)

    a) The IWR contains all the necessary performance data

    b) The IWR can be exported from *SiteManager* and converted by *SiteManager* Data Converter (SMDC) into a file readable by BIDDS.

    c) This method can only be used if the *SiteManager* system has not be modified. If they system has been modified the data collected through the binary indicator and the "Number of Crews" field will not show up on this report.

    d) There is a small window of time the IWR is available and contains all the monthly performance data. For this reason, this method relies on project personnel to export the IWR and email the file to the SMDC administrator.

    e) This report will always span a two calendar month period.

Recommendation 6.02: Develop a new report containing the required performance data which contains only a full calendar month of data.

    a) A new report is required if the *SiteManager* system is modified

    b) A new report can be created to contain the required performance data, regardless of whether any modifications have been made to the *SiteManager* system.

c) The new report can be created to eliminate the problem of having a small window of time to generate the report.

d) The new report should be created so that only a full calendar month of data is available. This will prevent data from being lost or duplicated. It will also eliminate the problem of a report spanning two calendar months.

e) The report can be generated by the SMDC administrator and this method does not rely on field personnel to obtain the report.

f) This method requires a new report to be created by the VDOT information technology division.

Recommendation 6.03: Investigate linking BIDDS to *SiteManager* data tables

a) If BIDDS could be linked to the *SiteManager* data tables, data would not need to be transferred from *SiteManager* into BIDDS.

b) BIDDS would not need to store any performance data but it would need to store project data and project characteristics.

c) This option needs to be investigated to determine its feasibility and impacts.

It is required that one of the three methods presented to resolve this issue be implemented.

10.3. Summary of Recommendations

The issues and the recommendations to resolve the issues have been presented and are in Table 10.1. The recommendations are summarized below. These recommendations were presented to Joseph Bouchey, an information technology specialist with VDOT, and his comments can be found in Appendix J.

1. It is recommended that *SiteManager* be used to collect performance data.

2. It is recommended that DBIs be distinguished from the list of bid items. This recommendation is optional but it will increase the ease of use when collecting performance data.

3. It is recommended that the current methods used to collect the quantity of work installed continue to be used. This recommendation is required to collect performance data.

4. It is recommended that modifications to the *SiteManager* system be implemented to collect the number of days performed by including a binary indicator.

5. It is recommended that modifications to the *SiteManager* system be implemented to collect the number of crews utilized to perform the work on a DBI by creating a "Number of Crews" filed.

6. It is recommended that a new report be developed to export performance data.

7. It is recommended that the feasibility of linking BIDDS to the *SiteManager* data tables be investigated. This could eliminate the need for data to be exported from *SiteManager*.

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Appendix A: Activity Scope of Work

Activity Scope of Work

Project Type: Road Reconstruction

Activity:	Scope of Work Includes all time required to:
Mobilization:	Mobilize equipment, men, office trailers, and any additional items which are necessary before work can begin.
Traffic Control:	Initially set up detours. This does not include maintaining detours.
Clearing and Grubbing:	Clear, grub, scalp, remove trees and stumps, and remove and dispose of all vegetation and debris within the limits set forth.
Demolition:	Demolish existing structure.
Milling:	Mill pavement and remove millings.
Roadway Excavation:	Cut or Fill soil in or around roadway.
Grading:	Perform both rough and fine grading procedures.
Box Culverts:	Excavate for box culvert, place pre-cast box culvert and/or form, tie and set rebar, pour concrete, and strip forms for box culvert, and backfill box culvert. Do not include concrete curing time.
Retaining walls:	Excavate for retaining wall footer, form, tie and place rebar, pour any concrete in retaining wall footer or retaining wall, strip forms. Can also include placement of dry rubble, or placement of precast concrete units. Time also includes backfilling behind retaining wall. Do not include concrete curing time.
Sub-grade Stabilization:	Excavate and replace material to stabilize sub-grade as well as placing geotextile fabric.
Base Stone:	Dump and spread base stone. Includes stone on the shoulders if operations are performed in unison.
Shoulders:	Dump and spread shoulder stone
Underdrain:	Excavate trench, place underdrain, and backfill trench. Also includes all time required to compact backfill.
Drain Pipes:	Excavate, place, and backfill drainage pipes and end sections. Also includes all time required to compact backfill.
Curb & Gutter:	Form, place and tie rebar, pour concrete, and strip forms. Do not include curing time.
Utilities:	Excavate, place, and backfill sanitary sewer pipe and manholes regardless of the number of manholes.
Asphalt Base Course:	Place base course of asphalt and roll and compact asphalt.
Asphalt Intermediate Course:	Place intermediate course of asphalt and roll and compact asphalt.
Asphalt Surface Course:	Place surface course of asphalt and roll and compact asphalt.
Approach Slabs:	Excavate, form, tie and place rebar, pour concrete, and strip forms. Do not include concrete curing time.

Pavement, Base, & Sub-grade Repairs:	Excavating, backfilling, placing stone, repaving, and/or patching areas needing repair.
Signs:	Place sign islands, sign posts (including foundations if required) and hang signs
Signals:	Place controller box, excavate foundations, place foundations, place signal poles, place signals, and pull wire.
Guardrails & Barriers	Drive guardrail posts, place guardrail, place guardrail terminals, and attach to fixed objects. Also includes pouring and/or placing median barrier and railing.
Drop Inlets	Excavate, place, backfill, and compact backfill for all drop inlets

Project Type: Bridge Reconstruction

Activity:	Scope of Work Includes all time required to:
Mobilization:	Mobilize equipment, men, office trailers, and any additional items which are necessary before work can begin.
Erect Temporary Structure:	Construct a temporary structure. This does not include the time required to maintain the temporary structure.
Clearing and Grubbing:	Clear, grub, scalp, remove trees and stumps, and remove and dispose of all vegetation and debris within the limits set forth.
Cofferdams:	Drive sheet piling or form and pour concrete. Do no include delay days or time required to maintain cofferdam.
Remove Existing Structure:	Demolish and remove existing structure and dispose of all debris.
Pile Driving:	Drive piles, cut off excess length, and weld pile caps. Do not include time required for test piles.
Structural Excavation:	Excavate required amount of soil.
Substructure Concrete:	Form, tie and place rebar, place concrete, strip forms. Do not include time required for concrete to cure.
Concrete Beams:	Place concrete beam.
Structural Steel:	Place Steel and torque bolts.
Deck Joints:	Assemble and place joints
Construct Deck:	Place deck pans, form overhangs, Form deck, tie and place rebar, place concrete, strip forms, and remove overhang forms. Do not include time required for concrete to cure. Do not include time required to pour sidewalk or parapet walls.
Parapets and Railings:	Form if required, tie and place rebar, pour concrete, strip forms if required, and place aluminum railing if required.
Deck Grooving:	Groove deck
Slop Protection:	Place concrete slope protection or riprap
Utilities:	Excavate, place, and backfill sanitary sewer pipe and manholes regardless of the number of manholes.

Guardrails & Barriers:	Drive guardrail posts, place guardrail, place guardrail terminals, and attach to fixed objects. Also includes pouring and/or placing median barrier and railing.
Remove Temporary Structure:	Remove temporary structure. Do no include time required to maintain structure.

Appendix B: Installed Work Report Data

cont_id	prj_nbr	catg_nbr	ln_itm_nbr	itm_cd	desc1	rpt_qty	unt_pric	cms_uid	dwr_dt	loc_instld	auth_ind	supl_desc1	unt_t	user_nm	fed_st_prj_nbr	supl_desc2	est_nbr	qty_instl_to_dt
6M804BRA39593	M804BRA39593	2	260	125	GRADING	0	64000	STGRB001	20051019	grading	Y		LS	GEORGE R. BEZOLD	0018-003-1006, SR01			0.2
6M804BRA39593	M804BRA39593	2	260	125	GRADING	0	64000	STGRB001	20051025	grading	Y		LS	GEORGE R. BEZOLD	0018-003-1006, SR01			0.2
6M804BRA39593	M804BRA39593	2	260	125	GRADING	0	64000	STGRB001	20051026	grading	Y		LS	GEORGE R. BEZOLD	0018-003-1006, SR01			0.2
6M804BRA39593	M804BRA39593	2	260	125	GRADING	0	64000	STGRB001	20051027	grading	Y		LS	GEORGE R. BEZOLD	0018-003-1006, SR01			0.2
6M804BRA39593	M804BRA39593	2	260	125	GRADING	0	64000	STGRB001	20051028	grading	Y		LS	GEORGE R. BEZOLD	0018-003-1006, SR01			0.2
6M804BRA39593	M804BRA39593	2	270	140	BORROW EXCAVATION	288	12	STGRB001	20051025	Embankment	Y		CY	GEORGE R. BEZOLD	0018-003-1006, SR01			0
6M804BRA39593	M804BRA39593	2	270	140	BORROW EXCAVATION	204	12	STGRB001	20051026	Embankment	Y		CY	GEORGE R. BEZOLD	0018-003-1006, SR01			0
6M804BRA39593	M804BRA39593	2	270	140	BORROW EXCAVATION	1248	12	STGRB001	20051027	embankment	Y		CY	GEORGE R. BEZOLD	0018-003-1006, SR01			0
6M804BRA39593	M804BRA39593	2	270	140	BORROW EXCAVATION	1044	12	STGRB001	20051028	embankment	Y		CY	GEORGE R. BEZOLD	0018-003-1006, SR01			0
6M804BRA39593	M804BRA39593	2	340	1300	30" PIPE	20	200	STGRB001	20051012	111+24	Y		LF	GEORGE R. BEZOLD	0018-003-1006, SR01			0
6M804BRA39593	M804BRA39593	2	340	1300	30" PIPE	40	200	STGRB001	20051013	111+24	Y		LF	GEORGE R. BEZOLD	0018-003-1006, SR01			0
6M804BRA39593	M804BRA39593	2	490	24278	GROUP 2 CHANNELIZING	10	0.44	STGRB001	20051011	as needed	Y		DAY	GEORGE R. BEZOLD	0018-003-1006, SR01			70
6M804BRA39593	M804BRA39593	2	490	24278	GROUP 2 CHANNELIZING	10	0.44	STGRB001	20051012	as needed	Y		DAY	GEORGE R. BEZOLD	0018-003-1006, SR01			70
6M804BRA39593	M804BRA39593	2	490	24278	GROUP 2 CHANNELIZING	10	0.44	STGRB001	20051013	as needed	Y		DAY	GEORGE R. BEZOLD	0018-003-1006, SR01			70
6M804BRA39593	M804BRA39593	2	490	24278	GROUP 2 CHANNELIZING	10	0.44	STGRB001	20051014	as needed	Y		DAY	GEORGE R. BEZOLD	0018-003-1006, SR01			70
6M804BRA39593	M804BRA39593	2	490	24278	GROUP 2 CHANNELIZING	10	0.44	STGRB001	20051015	as needed	Y		DAY	GEORGE R. BEZOLD	0018-003-1006, SR01			70
6M804BRA39593	M804BRA39593	2	490	24278	GROUP 2 CHANNELIZING	10	0.44	STGRB001	20051016	as needed	Y		DAY	GEORGE R. BEZOLD	0018-003-1006, SR01			70
6M804BRA39593	M804BRA39593	2	490	24278	GROUP 2 CHANNELIZING	10	0.44	STGRB001	20051017	as needed	Y		DAY	GEORGE R. BEZOLD	0018-003-1006, SR01			70
6M804BRA39593	M804BRA39593	2	490	24278	GROUP 2 CHANNELIZING	10	0.44	STGRB001	20051018	as needed	Y		DAY	GEORGE R. BEZOLD	0018-003-1006, SR01			70
6M804BRA39593	M804BRA39593	2	490	24278	GROUP 2 CHANNELIZING	10	0.44	STGRB001	20051019	as needed	Y		DAY	GEORGE R. BEZOLD	0018-003-1006, SR01			70
6M804BRA39593	M804BRA39593	2	490	24278	GROUP 2 CHANNELIZING	10	0.44	STGRB001	20051020	as needed	Y		DAY	GEORGE R. BEZOLD	0018-003-1006, SR01			70
6M804BRA39593	M804BRA39593	2	490	24278	GROUP 2 CHANNELIZING	10	0.44	STGRB001	20051021	as needed	Y		DAY	GEORGE R. BEZOLD	0018-003-1006, SR01			70
6M804BRA39593	M804BRA39593	2	490	24278	GROUP 2 CHANNELIZING	10	0.44	STGRB001	20051022	as needed	Y		DAY	GEORGE R. BEZOLD	0018-003-1006, SR01			70
6M804BRA39593	M804BRA39593	2	490	24278	GROUP 2 CHANNELIZING	10	0.44	STGRB001	20051023	as needed	Y		DAY	GEORGE R. BEZOLD	0018-003-1006, SR01			70
6M804BRA39593	M804BRA39593	2	490	24278	GROUP 2 CHANNELIZING	17	0.44	STGRB001	20051024	as needed	Y		DAY	GEORGE R. BEZOLD	0018-003-1006, SR01			70
6M804BRA39593	M804BRA39593	2	490	24278	GROUP 2 CHANNELIZING	17	0.44	STGRB001	20051025	as needed	Y		DAY	GEORGE R. BEZOLD	0018-003-1006, SR01			70
6M804BRA39593	M804BRA39593	2	490	24278	GROUP 2 CHANNELIZING	17	0.44	STGRB001	20051026	as needed	Y		DAY	GEORGE R. BEZOLD	0018-003-1006, SR01			70
6M804BRA39593	M804BRA39593	2	490	24278	GROUP 2 CHANNELIZING	17	0.44	STGRB001	20051027	as needed	Y		DAY	GEORGE R. BEZOLD	0018-003-1006, SR01			70
6M804BRA39593	M804BRA39593	2	490	24278	GROUP 2 CHANNELIZING	17	0.44	STGRB001	20051028	as needed	Y		DAY	GEORGE R. BEZOLD	0018-003-1006, SR01			70
6M804BRA39593	M804BRA39593	2	490	24278	GROUP 2 CHANNELIZING	17	0.44	STGRB001	20051029	as needed	Y		DAY	GEORGE R. BEZOLD	0018-003-1006, SR01			70
6M804BRA39593	M804BRA39593	2	490	24278	GROUP 2 CHANNELIZING	17	0.44	STGRB001	20051030	as needed	Y		DAY	GEORGE R. BEZOLD	0018-003-1006, SR01			70
6M804BRA39593	M804BRA39593	2	500	24282	FLAGGER SERVICE	8	14	STGRB001	20051011	project	Y		HR	GEORGE R. BEZOLD	0018-003-1006, SR01			139
6M804BRA39593	M804BRA39593	2	500	24282	FLAGGER SERVICE	20.5	14	STGRB001	20051012	project	Y		HR	GEORGE R. BEZOLD	0018-003-1006, SR01			139
6M804BRA39593	M804BRA39593	2	500	24282	FLAGGER SERVICE	20	14	STGRB001	20051013	project	Y		HR	GEORGE R. BEZOLD	0018-003-1006, SR01			139
6M804BRA39593	M804BRA39593	2	500	24282	FLAGGER SERVICE	4	14	STGRB001	20051014	project	Y		HR	GEORGE R. BEZOLD	0018-003-1006, SR01			139
6M804BRA39593	M804BRA39593	2	500	24282	FLAGGER SERVICE	16	14	STGRB001	20051017	project (for signals)	Y		HR	GEORGE R. BEZOLD	0018-003-1006, SR01			139
6M804BRA39593	M804BRA39593	2	500	24282	FLAGGER SERVICE	20	14	STGRB001	20051018	project	Y		HR	GEORGE R. BEZOLD	0018-003-1006, SR01			139
6M804BRA39593	M804BRA39593	2	500	24282	FLAGGER SERVICE	20	14	STGRB001	20051019	project	Y		HR	GEORGE R. BEZOLD	0018-003-1006, SR01			139
6M804BRA39593	M804BRA39593	2	500	24282	FLAGGER SERVICE	7	14	STGRB001	20051025	project	Y		HR	GEORGE R. BEZOLD	0018-003-1006, SR01			139
6M804BRA39593	M804BRA39593	2	500	24282	FLAGGER SERVICE	5	14	STGRB001	20051026	project	Y		HR	GEORGE R. BEZOLD	0018-003-1006, SR01			139
6M804BRA39593	M804BRA39593	2	500	24282	FLAGGER SERVICE	10	14	STGRB001	20051027	project	Y		HR	GEORGE R. BEZOLD	0018-003-1006, SR01			139
6M804BRA39593	M804BRA39593	2	500	24282	FLAGGER SERVICE	10	14	STGRB001	20051028	project	Y		HR	GEORGE R. BEZOLD	0018-003-1006, SR01			139
6M804BRA39593	M804BRA39593	2	590	27505	TEMP. SILT FENCE	50	2.9	STGRB001	20051012	left	Y		LF	GEORGE R. BEZOLD	0018-003-1006, SR01			850
6M804BRA39593	M804BRA39593	2	590	27505	TEMP. SILT FENCE	100	2.9	STGRB001	20051024	left	Y		LF	GEORGE R. BEZOLD	0018-003-1006, SR01			850
6M804BRA39593	M804BRA39593	2	590	27505	TEMP. SILT FENCE	73	2.9	STGRB001	20051024	left	Y		LF	GEORGE R. BEZOLD	0018-003-1006, SR01			850

Appendix C: Sample Data Collection Form

Project Number: (FO) 0081-080-117, N501, B627   Route Number: 81   Project Type: Widening and Bridge Recon   Project Setting: GS-5   Project Award Amount: $1,282,314.90

District/County: Salem / Roanoke   Project Description: 0.40 Mile Pavement Widening and Structure Repair on Rte. 419 and Rte. 81 Ramps   Project As-Built Cost:

Activity ID #	Activity Description	Actual Start	Actual Finish	Total Quantity w/ units	Week # 1 10/10	10/11	10/12	10/13	10/14	Week # 2 10/15	10/16	10/17	10/18	10/19	10/20	10/21	Week # 3 10/22	10/23	10/24	10/25	10/26	10/27	10/28	Week # 4 10/29	10/30	10/31	11/1	11/2	11/3	11/4	Week # 5 11/5	11/6	11/7	11/8	11/9	11/10	11/11
	MOBILIZATION																																					
00100	MOBILIZATION																																					
	TRAFFIC CONTROL																																					
24160	CONSTRUCTION SIGNS																																					
54512	CONSTR.PAVE.MARK.(TY.D,CL.II)4"																																					
54552	CONSTR.PAVE.MARK.(TY.F,CL.II)4"																																					
	DEMOLITION																																					
24430	DEMOLITION OF PAVEMENT (FLEXIBLE)																																					
24500	REMOVE EXIST. CONCRETE MEDIAN																																					
24501	REMOVE EXIST. CG-2 CURB																																					
	EXCAVATION																																					
00128	EXTRA EXCAVATION																																					
	DROP INLETS & DRAINAGE PIPES																																					
01180	18" PIPE																																					
07508	DROP INLET DI-7																																					
	CURB & GUTTER																																					
12020	STD. CURB CG-2																																					
12022	RADIAL CURB CG-2																																					
	GRADING																																					
00125	GRADING																																					
	STONE BASE & SHOLDERS																																					
10065	AGGR. MATL. NO. 1																																					
10128	AGGR. BASE MATL. TY. I NO. 21B																																					
	MILLING																																					
10630	FLEXIBLE PAVEMENT PLANING																																					
	ASPHALT BASE COURSE																																					
10612	ASPH.CONC.BASE CR. TY. BM-25.0																																					
	ASPHALT INTERMEDIATE COURSE																																					
10610	ASPHALT CONCRETE TY. IM-19.0A																																					
	ASPHALT SURFACE COURSE																																					
10635	ASPHALT CONCRETE TY. SM-9.5A																																					
10636	ASPHALT CONCRETE TY. SM-9.5D																																					
	BARRIERS & GUARDRAIL																																					
13320	GUARDRAIL GR-2																																					
13323	GUARDRAIL GR-2A																																					
13331	RAD. GUARDRAIL GR-2																																					
	PAVEMENT MARKINGS																																					
54049	TY.B CL.III PAVE.LINE MARK.4"																																					
54075	TY.B CL.VI PAVE. LINE MARK. 4"																																					
54076	TY.B CL.VI PAVE. LINE MARK. 6"																																					
54077	TY.B CL.VI PAVE. LINE MARK. 8"																																					
	REMOVE TEMPORARY STRUCTURE																																					
68900	NS REM. PORT.OF EX.STR.																																					
	SURFACE PATCHING																																					
68320	TYPE B PATCHING																																					
68330	TYPE C PATCHING																																					
	DECK JOINTS																																					
68572	EXPANSION JOINT RECONSTRUCTION																																					
68574	CLEAN AND RESEAL EXPANSION JOINT																																					
	DECK GROVING																																					
68090	BRIDGE DECK GROOVING																																					
	REMOVAL TRAFFIC CONTROL																																					

Appendix D: *SiteManager* Data Converter Field Personnel Training

SiteManager Data Converter Field Personnel Training

TR-0603

April 2006

Daniel W. Rich
John C. Hildreth
Virginia Tech

Abstract

A Performance Time Data (PTD) system has been developed to collect, store, and report historical performance time data from VDOT projects. Data for the system will be collected by field personnel using *SiteManager*. This will require that the field personnel understand the collection procedures end use of the data such that the necessary information is accurately provided. This document describes the training designed to provide the necessary data collection knowledge to field personnel.

Introduction

The VDOT – VT Partnership for Project Scheduling (VPPS) has developed a Performance Time Data (PTD) system to maintain historical performance time data collected from VDOT projects. The system is based on published FHWA recommendations for determining contract time. It is designed to provide performance time data to assist VDOT schedulers in estimating activity durations for pre-advertisement schedules.

The performance time data used to populate the database will be collected using *SiteManager*. Alternative methods for *SiteManager* use are required to meet the data needs. It is not necessary to collect additional data, but comprehensive data collection procedures are needed to provide the required time-related information.

Data Description

The historical performance time data reported by the database will be daily installed quantities (DIQ) and active crew days (ACD). DIQ is the quantity of work for each day work is performed on an item. ACD are days during which a crew is actively pursuing completion of a work item. For this reason, the daily performance time data needed includes, the quantity of work placed, the time required to place the quantity of work, and the number of crews utilized.

Data Collection Process

The alternative methods will apply only to Driving Bid Items (DBIs), not every bid item. DBIs are those that are significant to the completion of a project. The progress of a DBI is a reflection of project progress. Eight project types with DBIs have been defined, as the list of DBIs vary by project type.

Prior to initiating data collection, project field personnel on a PTD demonstration project will be provided a list of DBIs for the project. A sample list of bid items from a road and bridge reconstruction project type can be found in the attached Table 1. Approximately one third of the bid items are driving and are shown in bold.

The daily work report (DWR) is currently used to track the daily installed quantity of each bid item. Performance time data will be collected in exactly the same manner. All performance time data will be collected in the daily work report under the work items tab. Alternative methods must be used to accurately collect the number of active crew days. These methods will not alter the sum of the quantity placed. To collect this data, the quantity installed by each crew must be recorded, even if this quantity is zero. A screen shot of a zero quantity entry can be found in Figure 1. This is different than making no entry at all, which can be seen in Figure 2. By entering the quantity installed by each crew, the number of entries can be used to determine number of active crew days performed on a DBI. This presents three situations for which data may be collected:

	Situation	**Data Required**
1	Work is performed by a single crew and results in a quantity	The resulting quantity is recorded in the "Quantity Placed" field of the DWR
2	Work is performed by a single crew and results in zero quantity	The resulting zero quantity is recorded in the "Quantity Placed" field of the DWR
3	Work performed by multiple crews	A resulting quantity for each crew is recorded in the "Quantity Placed" field of the DWR

Table 1: Bid Items for Sample Bridge and Roadway Reconstruction Project

Bid Item No.	Description	Bid Item No.	Description
00100	**MOBILIZATION**	27430	SILTATION CONTROL EXCAVATION
00125	**GRADING**	27505	TEMP. SILT FENCE
00140	**BORROW EXCAVATION**	27506	TEMP. FILTER BARRIER
00270	SELECT MATL. TY. I MIN. CBR-30	51950	TEMP. SIGNALIZATION
00306	NS SELECT MATERIAL SELECT MATERIAL 8"	54105	ERADICATION OF EXIST. PAVEMENT MARKING
00591	**COMB. UNDERDRAIN CD-2**	54242	TEMP. PAVE. MARKER 2 WAY
00595	OUTLET PIPE	54550	CONSTR.PAVE.MARK. (TY.F,CL.I)4"
00596	ENDWALL EW-12	54554	CONSTR.PAVE.MARK. (TY.F,CL.I)8"
01150	**15" PIPE**	54562	CONSTR.PAVE.MARK. (TY.F,CL.I)24"
01240	**24" PIPE**	**60404**	**CONCRETE CLASS A4**
01300	**30" PIPE**	**60490**	**BRIDGE DECK GROOVING**
06241	24" END SECTION ES-1	61705	EPOXY COATED REINF. STEEL
06301	30" END SECTION ES-1	**61812**	**STR.STEEL PLATE GIRDER ASTM A709 GRADE**
07508	DROP INLET DI-7	**62015**	**RAILING, KANSAS CORRAL**
09150	EROSION CONTROL STONE CLASS I, EC-1	**64011**	**STRUCTURE EXCAVATION**
10128	**AGGR. BASE MATL. TY. I NO. 21B**	64030	POROUS BACKFILL
10607	**ASPHALT CONCRETE TY. SM-12.5A**	64036	PIPE UNDERDRAIN 6"
10612	**ASPHALT CONCRETE BASE COURSE TY. BM-25.**	**64110**	**STEEL PILES 10"**
11070	NS SAW CUT SAW CUT ASPHALT CONC. 6"	64755	PILE POINT FOR 10" STEEL PILE
13212	R/W MONUMENT RM-2	**65013**	**CONCRETE CLASS A3**
13320	**GUARDRAIL GR-2**	65205	EPOXY COATED REINF. STEEL
13331	**RAD. GUARDRAIL GR-2**	66116	NS TEMP. CAUSEWAY TEMP. CAUSEWAY
13345	ALTERNATE BREAKWAY CABLE TERMINAL (GR-9	66116	NS TEMP. CAUSEWAY TEMP. CAUSEWAY
13383	FIXED OBJECT ATTACH. GR-FOA-1 TY. I	**66120**	**COFFERDAM**
24152	TYPE III BARRICADE 8'	**66239**	**DRY RIPRAP CL.II 38"**
24278	GROUP 2 CHANNELIZING DEVICES	66927	NS BRIDGE SUBSTRUCTURE BRIDGE
24282	FLAGGER SERVICE	66927	NS BRIDGE SUBSTRUCTURE BRIDGE
24297	TRAF. BARRIER SERVICE CONC. DOUBLE FACE	66927	NS BRIDGE SUBSTRUCTURE BRIDGE
24703	NS REMOVE EXIST REMOVE EXIST. GUARDRAIL	**67900**	**NS DISM. & REM. EXIST. STR. DISM.& REM.**
25506	FIELD OFFICE TY.II	67905	NS BRIDGE INCIDENTALS BRIDGE
27102	REGULAR SEED	68476	NS ENV.& WORKER PROTECT. ENV.& WORK.
27103	OVERSEEDING	68490	NS DISPOSAL OF MATERIAL DISPOSAL OF
27215	FERTILIZER(15-30-15)	68760	TRAF. BARRIER SERVICE CONC. SINGLE FACE
27250	LIME		
27422	DEWATERING BASIN		

Driving Bid Items shown in **bold**

Figure 1: Zero Quantity Entry

Figure 2: No Entry Being MadePotential

Data Collection Issues

The SiteManager system was designed to track quantities, not to track performance time. Therefore, special care must be taken to ensure the number of entries equals the number of crew days performed and the sum of the quantity installed is correct. The following situations may result in data collection issues:

1. It is standard practice to enter the percent complete for lump sum items on the day the estimate is being performed. This may not be a day the contractor worked on the DBI. By entering the percentage complete quantity on a day the contractor did not work, the number of quantity entries will not correspond with the number of active crew days.

2. There are times when an inspector may choose not to enter a quantity for payment to the contractor until a later date even though the contractor has placed a quantity. One example could be a failure by

the contractor to place the quantity with full adherence to the specifications causing the inspector to withhold payment until there is full adherence to the specifications. The inspector may then enter the quantity on a date when no work was performed on the activity. This will cause the total quantity installed to be correct, but the number of quantity entries will not correspond with the number of active crew days. This will produce inaccurate results.

3. If the inspector enters quantities for a DBI on a day when no work was performed to adjust the quantities to a correct value, the number of quantity entries will not correspond with the number of crew days. This will cause an extra active crew day to be attributed to the performance of that DBI.

Frequently Asked Questions

1. **What constitutes a crew?**

There are many ways a crew can be composed. A crew can range in size from one person to many persons. For this reason, project field personnel must determine what constitutes a crew. This determination can be made based on the crew composition normally used to complete the work. If the contractor personnel performing the work are abnormally smaller than the crew composition normally used, no performance time data needs to be recorded. No adjustments will be made for large crews.

2. **How are the number of crews determined?**

If there are two groups of workers actively pursuing work on a DBI in two separate locations, this can be considered as two crews. If there are two groups of workers actively pursuing work on two separate DBIs in the same location, these can be considered as two separate crews. If one crew splits to perform work on two separate DBIs, they can be considered as two crews. If two crews join to perform work on a single DBI in the same location, they can be considered as one crew.

3. **How are incidental items handled?**

If a crew is actively pursuing work to complete a DBI and then moves to actively pursue work on another DBI, performance time data needs to be collected for both DBIs on this day. If a crew or portions of a crew move to perform incidental items which are not significant to the overall completion of the work item, performance time data does not need to be collected for the incidental work.

4. **If the contractor works a small amount of time on a DBI, does performance time data need to be collected?**

There are various periods of time a crew may work on a DBI. On some days a crew may spend a full day and work overtime on a DBI and on other days they may work on a DBI for a short period of time. These situations require the project field personnel to determine when to record performance data for a DBI. If little time is spent on a DBI, the project field personnel must determine if the work performed is significant to the overall completion of the work item. Regardless of the time spent, if the work results in an installed quantity, that quantity should be recorded.

5. **What consideration is given to overtime?**

When a crew works overtime on a DBI, no adjustments need to be made to account for the extra amount of time spent performing the work.

6. **What if the contractor is working multiple shifts?**

If there are multiple shifts are being worked on a job and work is performed on a single DBI during each shift, a work item entry for this DBI needs to be made for each shift to collect the performance time data because each shift constitutes a day.

7. **How are active crew days collected for lump sum items?**

It is not necessary to estimate the percentage completed on a lump work item for each day work is performed. It is best to enter the monthly quantity on the last day which the crew actively pursued the work. When the monthly quantity is estimated on a day in which work is not performed, the last entry made may be changed to equal the percentage completed for the estimate period.

8. **Should performance time data be collected on days when materials are delivered?**

Accepting delivery and offloading materials is not considered actively pursuing the work.

9. **When do I stop collecting performance time data for a work item?**

When 100% of a work item has been paid for, no more performance time data needs to be collected for this item.

System Impacts

When the alternative methods described are used to collect the necessary performance time data, there are two effects on the *SiteManager* system:

1. The daily work report will increase in length since all daily quantities, including those that are zero, are included.
2. The estimate summary will also include zero quantity entries.

Field trials of these methods have shown that no function of *SiteManager* is compromised and all field personnel involved have reported positive experiences.

Data Uses

The data collected from *SiteManager* will be used to populate the database with performance time data. This data includes collecting the daily installed quantity and the number of active crew days expended during the performance of the DBI. The total quantity placed for a DBI is the sum of the recorded quantity. The total number of crew days is the number of work item entries for a DBI.

Feel free to contact either Dr. John Hildreth or Ms. Jennifer Stephens with any questions by email at scheduling@vt.edu or by phone at (540) 231-0923.

Examples

Example 1: One crew laid 15" pipe for a week. The following table specifies the work performed each day.

Monday	Tuesday	Wednesday	Thursday	Friday
20 LF	35 LF	45 LF	No Work	15 LF

The DBI is 01150 15" PIPE and the daily quantity entries into *SiteManager* are:

Monday:	20 LF
Tuesday:	35 LF
Wednesday:	45 LF
Thursday:	None
Friday:	15 LF

Example 2: One crew laid 24" pipe for a week. The following table represents the work performed each day.

Mon	Tue	Wed	Thu	Fri
Excavated Trench	Excavated Trench	45 LF	No Work	Excavated Trench

The DBI is 01240 24" PIPE and the daily quantity entries into *SiteManager* are:

Monday:	0 LF
Tuesday:	0 LF
Wednesday:	45 LF
Thursday:	None
Friday:	0 LF

Example 3: Work was being performed on three separate concrete footers for a bridge. The following table represents the work performed each day.

	Mon	Tue	Wed	Thu	Fri
Crew 1	Formed Footer	Formed Footer	No Work	No Work	65 CY
Crew 2	Formed Footer	No Work	No Work	75 CY	No Work
Crew 3	No Work	No Work	No Work	Formed Footer	80 CY

The DBI is 65013 CONCRETE CLASS A3 and the daily quantity entries into *SiteManager* are:

Monday:	0 CY for Crew 1 <u>and</u> 0 CY for Crew 2
Tuesday:	0 CY for Crew 1
Wednesday:	None
Thursday:	75 CY for Crew 2 <u>and</u> 0 CY for Crew 3
Friday:	65 CY for Crew 1 <u>and</u> 80 CY for Crew 3

Appendix E: Type I Statistical Analysis Table

Order No.	Ordered Data	Sample No.	Rank	t_j	$t_j(t_j^2-1)$
1	0.00	1	25		
2	0.00	1	25		
3	0.00	1	25		
4	0.00	1	25		
5	0.00	1	25		
6	0.00	1	25		
7	0.00	1	25		
8	0.00	1	25		
9	0.00	1	25		
10	0.00	1	25		
11	0.00	1	25		
12	0.00	1	25		
13	0.00	1	25		
14	0.00	1	25		
15	0.00	1	25		
16	0.00	1	25		
17	0.00	1	25		
18	0.00	1	25		
19	0.00	1	25		
20	0.00	1	25		
21	0.00	1	25		
22	0.00	1	25		
23	0.00	1	25		
24	0.00	1	25		
25	0.00	2	25	50	124950
26	0.00	2	25		
27	0.00	2	25		
28	0.00	2	25		
29	0.00	2	25		
30	0.00	2	25		
31	0.00	2	25		
32	0.00	2	25		
33	0.00	2	25		
34	0.00	2	25		
35	0.00	2	25		
36	0.00	2	25		
37	0.00	2	25		
38	0.00	2	25		
39	0.00	2	25		
40	0.00	2	25		
41	0.00	2	25		
42	0.00	2	25		
43	0.00	2	25		
44	0.00	2	25		
45	0.00	2	25		
46	0.00	2	25		
47	0.00	2	25		
48	0.00	2	25		
49	0.00	2	25		
50	0.00	2	25		

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Order No.	Ordered Data	Sample No.	Rank	t_j	$t_j(t_j^2-1)$
51	0.05	1	51.5	2	6
52	0.05	2	51.5		
53	0.10	1	54	3	24
54	0.10	1	54		
55	0.10	2	54		
56	0.20	2	56.5	2	6
57	0.20	2	56.5		
58	0.25	1	58		
59	0.50	1	61	3	24
60	0.50	2	61		
61	0.50	2	61		
62	1.00	1	70	17	4896
63	1.00	1	70		
64	1.00	1	70		
65	1.00	1	70		
66	1.00	1	70		
67	1.00	1	70		
68	1.00	1	70		
69	1.00	1	70		
70	1.00	1	70		
71	1.00	2	70		
72	1.00	2	70		
73	1.00	2	70		
74	1.00	2	70		
75	1.00	2	70		
76	1.00	2	70		
77	1.00	2	70		
78	1.00	2	70		
79	1.50	2	79		
80	3.00	1	80		
81	4.73	1	81.5	2	6
82	4.73	2	81.5		
83	5.50	1	83.5	2	6
84	5.50	2	83.5		
85	5.80	2	85		
86	6.00	1	86.5	2	6
87	6.00	2	86.5		
88	8.00	1	91.5	8	504
89	8.00	1	91.5		
90	8.00	1	91.5		
91	8.00	1	91.5		
92	8.00	2	91.5		
93	8.00	2	91.5		
94	8.00	2	91.5		
95	8.00	2	91.5		
96	10.00	1	96.5	2	6
97	10.00	2	96.5		
98	12.00	1	98		

Order No.	Ordered Data	Sample No.	Rank	t_j	$t_j(t_j^2-1)$
99	13.33	1	99.5	2	6
100	13.33	2	99.5		
101	13.50	1	101.5	2	6
102	13.50	2	101.5		
103	14.00	1	103		
104	15.50	1	104.5	2	6
105	15.50	2	104.5		
106	16.00	1	106.5	2	6
107	16.00	2	106.5		
108	18.00	1	108.5	2	6
109	18.00	2	108.5		
110	18.67	1	110.5	2	6
111	18.67	2	110.5		
112	19.55	2	112		
113	21.33	2	113		
114	21.50	1	114.5	2	6
115	21.50	2	114.5		
116	23.00	1	116.5	2	6
117	23.00	2	116.5		
118	26.55	1	118		
119	30.00	1	119.5	2	6
120	30.00	2	119.5		
121	32.26	1	121.5	2	6
122	32.26	2	121.5		
123	40.00	1	123.5	2	6
124	40.00	2	123.5		
125	43.00	1	125.5	2	6
126	43.00	2	125.5		
127	45.50	1	127.5	2	6
128	45.50	2	127.5		
129	56.00	1	129.5	2	6
130	56.00	2	129.5		

SUM: 130518

Appendix F: Type II Statistical Analysis Table

Order No.	Ordered Data	Sample No.	Rank	t_j	$t_j(t_j^2-1)$
1	0.00	1	21.5		
2	0.00	2	21.5		
3	0.00	2	21.5		
4	0.00	2	21.5		
5	0.00	2	21.5		
6	0.00	2	21.5		
7	0.00	2	21.5		
8	0.00	2	21.5		
9	0.00	2	21.5		
10	0.00	2	21.5		
11	0.00	2	21.5		
12	0.00	2	21.5		
13	0.00	2	21.5		
14	0.00	2	21.5		
15	0.00	2	21.5		
16	0.00	2	21.5		
17	0.00	2	21.5		
18	0.00	2	21.5		
19	0.00	2	21.5		
20	0.00	2	21.5		
21	0.00	2	21.5	42	74046
22	0.00	2	21.5		
23	0.00	2	21.5		
24	0.00	2	21.5		
25	0.00	2	21.5		
26	0.00	2	21.5		
27	0.00	2	21.5		
28	0.00	2	21.5		
29	0.00	2	21.5		
30	0.00	2	21.5		
31	0.00	2	21.5		
32	0.00	2	21.5		
33	0.00	2	21.5		
34	0.00	2	21.5		
35	0.00	2	21.5		
36	0.00	2	21.5		
37	0.00	2	21.5		
38	0.00	2	21.5		
39	0.00	2	21.5		
40	0.00	2	21.5		
41	0.00	2	21.5		
42	0.00	2	21.5		
43	0.02	2	43		
44	0.03	2	44		
45	0.10	1	46		
46	0.10	2	46		
47	0.10	2	46		
48	0.11	2	48		
49	0.15	1	49.5	2	6
50	0.15	2	49.5		

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Order No.	Ordered Data	Sample No.	Rank	t_j	$t_j(t_j^2-1)$
51	0.18	2	51		
52	0.30	1	52		
53	0.45	1	53		
54	0.50	1	54.5	2	6
55	0.50	1	54.5		
56	0.55	2	56		
57	0.60	1	57		
58	0.90	2	58		
59	0.91	2	59		
60	1.00	1	61.5	4	60
61	1.00	1	61.5		
62	1.00	1	61.5		
63	1.00	2	61.5		
64	1.50	2	64		
65	1.81	1	65		
66	2.00	1	66		
67	2.16	2	67		
68	2.25	2	68		
69	2.42	2	69		
70	2.44	1	70.5	2	6
71	2.44	2	70.5		
72	3.25	1	72		
73	5.00	2	73		
74	5.45	2	74		
75	5.50	2	75		
76	5.77	2	76		
77	7.32	2	77		
78	9.00	1	78		
79	9.41	1	79.5	2	6
80	9.41	2	79.5		
81	10.43	1	81		
82	11.06	1	82		
83	11.13	2	83		
84	14.63	1	84		
85	14.64	1	85		
86	15.46	1	86		
87	15.70	2	87		
88	17.50	1	88.5	2	6
89	17.50	2	88.5		
90	18.11	1	90.5	2	6
91	18.11	2	90.5		
92	18.88	2	92		
93	21.40	2	93		
94	21.79	1	94		
95	21.96	1	95.5	2	6
96	21.96	1	95.5		
97	22.00	2	97		
98	22.04	1	98.5	2	6
99	22.04	2	98.5		
100	23.64	2	100		

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Order No.	Ordered Data	Sample No.	Rank	t_j	$t_j(t_j^2-1)$
101	23.65	1	101		
102	23.97	2	102		
103	24.00	1	103.5	2	6
104	24.00	2	103.5		
105	24.09	1	105		
106	24.50	2	106		
107	25.00	2	107		
108	29.22	1	108		
109	29.40	2	109		
110	31.12	1	110		
111	31.20	2	111		
112	31.25	1	112		
113	32.67	1	113		
114	33.50	2	114		
115	33.60	1	115		
116	34.60	1	116.5	2	6
117	34.60	2	116.5		
118	39.43	2	118		
119	39.53	2	119		
120	42.50	2	120		
121	42.58	2	121		
122	42.80	1	122		
123	47.00	2	123		
124	48.17	2	124		
125	49.75	1	125		
126	51.57	1	126		
127	52.00	2	127		
128	52.43	2	128		
129	53.00	1	129		
130	53.46	1	130		
131	56.96	1	131		
132	59.15	1	132.5	2	6
133	59.15	2	132.5		
134	63.35	1	134.5	2	6
135	63.35	2	134.5		
136	63.50	1	136		
137	65.92	1	137		
138	67.00	1	138.5	2	6
139	67.00	2	138.5		
140	71.29	1	140		
141	75.12	1	141.5	2	6
142	75.12	2	141.5		
143	80.00	2	143		
144	85.83	1	144		
145	91.67	1	145		
146	94.00	2	146		
147	94.34	2	147		
148	101.48	2	148		
149	106.88	2	149		
150	113.79	1	150		

Order No.	Ordered Data	Sample No.	Rank	t_j	$t_j(t_j^2-1)$
151	119.26	2	151		
152	121.67	1	152.5	2	6
153	121.67	2	152.5		
154	125.00	1	154		
155	131.90	1	155		
156	134.40	1	156.5	2	6
157	134.40	2	156.5		
158	140.85	1	158.5	2	6
159	140.85	2	158.5		
160	150.00	1	160		
161	150.24	1	161.5	2	6
162	150.24	2	161.5		
163	152.83	1	163		
164	175.00	1	164		
165	180.00	2	165		
166	192.50	1	166.5	2	6
167	192.50	2	166.5		
168	246.70	1	168.5	2	6
169	246.70	2	168.5		
170	264.36	1	170		
171	274.00	1	171.5	2	6
172	274.00	2	171.5		
173	277.12	1	173		
174	285.71	1	174		
175	285.72	1	175		
176	296.00	1	176.5	2	6
177	296.00	2	176.5		
178	303.34	2	178		
179	310.08	2	179		
180	350.32	1	180.5	2	6
181	350.32	2	180.5		
182	355.00	2	182		
183	369.32	2	183		
184	385.52	1	184		
185	399.98	1	185		
186	414.00	1	186		
187	470.00	2	187		
188	482.00	1	188		
189	556.00	1	189		
190	562.59	1	190		
191	575.00	1	191		
192	716.00	1	192		
193	907.00	2	193		
194	1681.00	1	194		
195	4326.50	2	195		
196	4575.00	2	196		
197	10382.00	2	197		

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Appendix G: *SiteManager* Data Converter Code

Code on Sheet 1

```
' SiteManager Data Converter 1.01
' Written by Daniel W. Rich
' Date: Febuary 24th, 2006
'
'
Option Explicit
Public SMFileName As String
Public Valid As Boolean
Private Sub Browse_Click()
'Select SiteManager File to Convert
Dim SMFile As Object
    Set SMFile = Sheets("Data").SMFile
    SMFile.Enabled = True
'
' Get the name and location of the SM, IWR file
    SMFileName = Application _
        .GetOpenFilename("Text Files (*.txt), *.txt", 1, "File to Convert")
'
' If close is not selected, then write the file name to the
' SMFile text box
    If SMFileName <> "False" Then
        SMFile.Text = SMFileName
    End If
' Disable the SMFile text box
    SMFile.Enabled = False
'
End Sub
Private Sub BtHlp_Click()
'
' Show the help form when the Help button is clicked
    FormHelp.Show
'
End Sub

Private Sub Continue_Click()
'
'
'
Dim SMFile As Object 'The Installed Work Report (IWR) text file
Dim SMBook As Workbook 'The Workbook containing the IWR text file
Dim TargetBook As Workbook 'The Workbook containingg the new file
Dim SMDCBook As Workbook 'The Workbook containing the user imput
```

```
Dim ProjType As Object 'The ComboBox with Project Type
Dim Mo As Object 'The ComboBox with the Month
Dim Yr As Object 'The ComboBox with the Year
Dim Engl As Object 'The CheckBox with Standard Units
Dim Mtrc As Object 'The CheckBox with Metric Units
Dim PType As String 'The Text of the Project Type Selected
Dim r As Integer 'The row number in the SiteManager IWR file
Dim Trow As Integer 'the row number in the TargetBook
Dim Counter As Integer 'The time counter for each Driving Bid Item
Dim Conv As Variant 'the conversion factor if Metric
Dim SMQ As Long 'SiteManager Quantity counter for each DBI
Dim TQ As Long 'Total Quantity for each DBI
Dim BI As Long 'Bid Item Number
Dim RI As Long 'Bid Item Number record
Dim Result As Variant 'Result of DBI lookup value
Dim DBI As Range 'Range containing Driving Bid Items
Dim BidI As Range 'Range containing Bid Items in TargetBook
Dim LastDBIRow As Long 'Last Row on Driving Bid Item Sheet
Dim LastBidI As Long 'Last Row on TargetBook Sheet
Dim DBISheet As Worksheet 'Sheet containing the Driving Bid Items
Dim sh As Worksheet 'Sheet containing data in TargetBook
Dim FileSaveName As String 'The name of the File Being Saved
'
    Set SMDCBook = ActiveWorkbook
    Set SMFile = Sheets("Data").SMFile
    Set ProjType = Sheets("Data").ProjType
    Set Mo = Sheets("Data").Mo
    Set Yr = Sheets("Data").Yr
    Set Mtrc = Sheets("Data").Mtrc
    Set Engl = Sheets("Data").Engl
'
' Run the ValidateData sub rutine to Validate the data entered
    ValidateData
    If Valid = False Then Exit Sub
'
' Open the file name specified in the Browse Sub
    Workbooks.OpenText Filename:=SMFile.Text _
        , Tab:=True, FieldInfo:=Array(Array(1, 1), _
        Array(2, 1), Array(3, 1), Array(4, 1), Array(5, 1), Array(6, 1), Array(7, 1),
Array(8, 1), _
        Array(9, 1), Array(10, 5))
' Name the IWR text file workbook just opened
    Set SMBook = ActiveWorkbook
'
' Open a new workbook and name it Target Book
    Set TargetBook = Workbooks.Add
```

```vba
' Name sheet1 in TargetBook
    Set sh = TargetBook.Worksheets("Sheet1")
' Obtain the text of the Project Type Selected and match that text
' to the appropriate Sheet containing the Driving Bid Items
    PType = ProjType.Text
    Set DBISheet = SMDCBook.Worksheets(PType)
' Find the last row and select the range containing the Driving Bid
' Items and their description
    LastDBIRow = DBISheet.Range("a3").End(xlDown).Row
    Set DBI = DBISheet.Range("B3:F" & LastDBIRow)
'
    r = 2
    RI = 0
    Trow = 1
    SMQ = 0
'
' If Standard units of measurement is selected then execute the following
' routine
    If Engl = True Then
' While there is a number in the cell, complete this loop
        While        Application.WorksheetFunction.IsNumber(SMBook.Sheets(1).Cells(r,
5).Value)
' Select the bid item number and quantity from the from the SM file
            BI = SMBook.Sheets(1).Cells(r, 5).Value
            SMQ = SMBook.Sheets(1).Cells(r, 7).Value
' If the Bid Item on the current row is equal to the Bid Item on the
' previous row then increment r (row number) by one and increment
' Counter (Time Counter) by one, and add the quantity to the total
' quantity
            If BI = RI Then
                r = r + 1
                Counter = 1 + Counter
                TQ = TQ + SMQ
' If the Bid Item on the current row is not equal to the Bid Item on
' the previous row, but the Bid item on the previous row is a bid item
' (#>0) then enter the Project Number, Bid Item Number, Month, Year,
' Total Quantity, and the count of time in the appropriate cells.
            ElseIf RI > 0 Then
'  if result is not a error then BI was a driving bid item
                If IsError(Result) = False Then
                    sh.Range("A" & Trow).Value = SMBook.Sheets(1).Cells(2, 16).Value
                    sh.Range("B" & Trow).Value = RI
                    sh.Range("C" & Trow).Value = Mo.Text
                    sh.Range("D" & Trow).Value = Yr.Text
                    sh.Range("E" & Trow).Value = TQ
                    sh.Range("F" & Trow).Value = Counter
```

```
' Reset the Total Quantity to the quantity on the current row. Reset
' Counter to one.  Check to see if the bid item on the current row is
' a Driving Bid Item (if no #N/A will result). Increment r by 1 and
' increment Trow by one
                TQ = SMQ
                Counter = 1
                Result = Application.VLookup(BI, DBI, 2, False)
                r = r + 1
                RI = BI
                Trow = Trow + 1
' if result was a error then BI was not a driving bid item.  Check the
' Bid Item on the current row to see if it is a Driving Bid Item
            Else
                Result = Application.VLookup(BI, DBI, 2, False)
                Counter = 1
                TQ = SMQ
                r = r + 1
                RI = BI
            End If
' if RI <= 0 (was not a bid item number) then  check the bid item
' on the current row to see if t is a driving bid item
        Else
            Result = Application.VLookup(BI, DBI, 2, False)
            Counter = 1
            r = r + 1
            RI = BI
            SMQ = TQ
        End If
      Wend
' If Metric Units Are Selected
    Else
      While          Application.WorksheetFunction.IsNumber(SMBook.Sheets(1).Cells(r,
5).Value)
        BI = SMBook.Sheets(1).Cells(r, 5).Value
        SMQ = SMBook.Sheets(1).Cells(r, 7).Value
        If BI = RI Then
            r = r + 1
            Counter = 1 + Counter
            TQ = TQ + SMQ
        ElseIf RI > 0 Then
            If IsError(Result) = False Then
                Conv = Application.VLookup(RI, DBI, 5, False)
                sh.Range("A" & Trow).Value = SMBook.Sheets(1).Cells(2, 16).Value
                sh.Range("B" & Trow).Value = RI
                sh.Range("C" & Trow).Value = Mo.Text
                sh.Range("D" & Trow).Value = Yr.Text
```

```
            sh.Range("E" & Trow).Value = TQ * Conv
            sh.Range("F" & Trow).Value = Counter
            TQ = SMQ
            Counter = 1
            Result = Application.VLookup(BI, DBI, 2, False)
            r = r + 1
            RI = BI
            Trow = Trow + 1
          Else
            Result = Application.VLookup(BI, DBI, 2, False)
            Counter = 1
            TQ = SMQ
            r = r + 1
            RI = BI
          End If
        Else
          Result = Application.VLookup(BI, DBI, 2, False)
          Counter = 1
          r = r + 1
          RI = BI
          SMQ = TQ
        End If
      Wend
    End If
'
' Reformat the bid item numbers in TargetBook to have 5 numbers
    LastBidI = sh.Range("B1").End(xlDown).Row
    Set BidI = sh.Range("B1:B" & LastDBIRow)
    BidI.NumberFormat = "00000"
' get the name to save Target Book as and save it
    FileSaveName = Application.GetSaveAsFilename("Save New Database File", _
    "Text Files (*.txt), *.txt", 1, "Save New Database File File")
'
    TargetBook.SaveAs Filename:=FileSaveName, FileFormat:=xlText, _
        CreateBackup:=False
'
    SMBook.Close (False)
    TargetBook.Close (True)
'
End Sub

Private Sub Engl_Click()
' If Standard units are used, turn of the Metric Check Box and
' if Standard units are not used, turn on the Metric Check Box
If Engl = True Then
Mtrc = False
```

```
ElseIf Engl = False Then
Mtrc = True
End If
End Sub

Private Sub ExitSMDC_Click()
' Exit SMDC when exit button is clicked
ActiveWorkbook.Close SaveChanges:=False
End Sub

Private Sub ValidateData()
'
'
'
    Valid = True
'
' If there is no text in the SMFile text box data is not valid
    If SMFile.Text = "" Then
    MsgBox "No SiteManager File Has Been Chosen", vbOKOnly, "Invalid Data"
    Valid = False
    End If
'
' If no project type was selected then data is not valid
    If ProjType.ListIndex = -1 Then
    MsgBox "Project Type Has Not Been Selected", vbOKOnly, "Invalid Data"
    Valid = False
    End If
'
' If no estimate month was selected then data is not valid
    If Mo.ListIndex = -1 Then
    MsgBox "Estimate Month Has Not Been Specified", vbOKOnly, "Invalid Data"
    Valid = False
    End If
'
' If no estimate year was selected then data is not valid
    If Yr.ListIndex = -1 Then
    MsgBox "Estimate Year Has Not Been Specified", vbOKOnly, "Invalid Data"
    Valid = False
    End If
'
End Sub

Private Sub Mtrc_Click()
' If Metric units are used, turn of the Standard Check Box and
' if Metric units are not used, turn on the Standard Check Box
If Mtrc = True Then
```

```
Engl = False
ElseIf Mtrc = False Then
Engl = True
End If
End Sub
```

Code in This Workbook

Option Explicit

Private Sub Workbook_Open()
```
'
'
'

    Dim SMFile As Object
    Dim ProjType As Object
    Dim Mo As Object
    Dim Yr As Object
    Dim Engl As Object
    Dim Mtrc As Object
    Dim MyControl As CommandBarPopup
'
'

    Set ProjType = Sheets("Data").ProjType
    Set Mo = Sheets("Data").Mo
    Set Yr = Sheets("Data").Yr
    Set SMFile = Sheets("Data").SMFile
    Set Engl = Sheets("Data").Engl
    Set Mtrc = Sheets("Data").Mtrc
'
' Hide all the Driving Bid Items and Help File Worksheets
    Worksheets("New Road Construction").Visible = xlSheetVeryHidden
    Worksheets("New Bridge Construction").Visible = xlSheetVeryHidden
    Worksheets("Road Reconstruction").Visible = xlSheetVeryHidden
    Worksheets("Bridge Reconstruction").Visible = xlSheetVeryHidden
    Worksheets("Road Rehabilitation").Visible = xlSheetVeryHidden
    Worksheets("Bridge Rehabilitation").Visible = xlSheetVeryHidden
    Worksheets("Widening").Visible = xlSheetVeryHidden
    Worksheets("Overlay").Visible = xlSheetVeryHidden
    Worksheets("HelpSheet").Visible = xlSheetVeryHidden
'
' Populate the Project Type Combo Box
    ProjType.AddItem "New Road Construction"    'ListIndex Value 0
    ProjType.AddItem "New Bridge Construction"  'ListIndex Value 1
    ProjType.AddItem "Road Reconstruction"      'ListIndex Value 2
    ProjType.AddItem "Bridge Reconstruction"    'ListIndex Value 3
    ProjType.AddItem "Road Rehabilitation"      'ListIndex Value 4
    ProjType.AddItem "Bridge Rehabilitation"    'ListIndex Value 5
    ProjType.AddItem "Widening"                 'ListIndex Value 6
    ProjType.AddItem "Overlay"                  'ListIndex Value 7
'
```

```vb
' Populate the Estimate Year Combo Box
    Yr.AddItem "2005"       'ListIndex Value 0
    Yr.AddItem "2006"       'ListIndex Value 1
    Yr.AddItem "2007"       'ListIndex Value 2
    Yr.AddItem "2008"       'ListIndex Value 3
    Yr.AddItem "2009"       'ListIndex Value 4
    Yr.AddItem "2010"       'ListIndex Value 5
    Yr.AddItem "2011"       'ListIndex Value 6
    Yr.AddItem "2012"       'ListIndex Value 7
    Yr.AddItem "2013"       'ListIndex Value 8
    Yr.AddItem "2014"       'ListIndex Value 9
    Yr.AddItem "2015"       'ListIndex Value 10
'
' Populate the Estimate Month Combo Box
    Mo.AddItem "January"      'ListIndex Value 0
    Mo.AddItem "Febuary"      'ListIndex Value 1
    Mo.AddItem "March"       'ListIndex Value 2
    Mo.AddItem "April"       'ListIndex Value 3
    Mo.AddItem "May"        'ListIndex Value 4
    Mo.AddItem "June"       'ListIndex Value 5
    Mo.AddItem "July"       'ListIndex Value 6
    Mo.AddItem "August"      'ListIndex Value 7
    Mo.AddItem "September"     'ListIndex Value 8
    Mo.AddItem "October"      'ListIndex Value 9
    Mo.AddItem "November"      'ListIndex Value 10
    Mo.AddItem "December"      'ListIndex Value 11
'
' Clear the contents of the Drop Down Boxes if SMDC was saved
' with contents at the previous time
    ProjType.Style = fmStyleDropDownCombo
    Mo.Style = fmStyleDropDownCombo
    Yr.Style = fmStyleDropDownCombo
'Limit the values entered into the ComboBox's
    ProjType.Style = fmStyleDropDownList
    Mo.Style = fmStyleDropDownList
    Yr.Style = fmStyleDropDownList
'Combo box values are ListIndex values
    Mo.BoundColumn = 0
    ProjType.BoundColumn = 0
    Yr.BoundColumn = 0
'
' Text Box Contents
SMFile.Text = ""
'
' Turn on the Standard Units Checkbox
Engl = True
```

```
'
' Disable the Protection Feature for the Workbook
Set MyControl = Application.CommandBars.FindControl(ID:=30029)
MyControl.Enabled = False
'

End Sub
```

Module 1 Code

```
Sub EnableProtection()
'
    Dim Response As VbMsgBoxResult
    Dim Password As String
    Dim MyControl As CommandBarPopup
'
    Password = "password"
'
' check for password
    If InputBox("Please enter the password.") <> Password Then
        Response = MsgBox("Sorry, that is not the correct password.", vbCritical +
vbOKOnly, "Invalid Password")
        If Response = vbOK Then Exit Sub
    End If
'
' enable protection on the tools menu
    Set MyControl = Application.CommandBars.FindControl(ID:=30029)
    MyControl.Enabled = True
'
End Sub
```

Module 2 Code

```vba
Sub ShowWorksheets()
'
    Dim Response As VbMsgBoxResult
    Dim Password As String
    Dim MyControl As CommandBarPopup
'
    Password = "password"
'
' check for password
    If InputBox("Please enter the password.") <> Password Then
        Response = MsgBox("Sorry, that is not the correct password.", vbCritical + vbOKOnly, "Invalid Password")
        If Response = vbOK Then Exit Sub
    End If
'
' show all the worksheets
    Worksheets("New Road Construction").Visible = True
    Worksheets("New Bridge Construction").Visible = True
    Worksheets("Road Reconstruction").Visible = True
    Worksheets("Bridge Reconstruction").Visible = True
    Worksheets("Road Rehabilitation").Visible = True
    Worksheets("Bridge Rehabilitation").Visible = True
    Worksheets("Widening").Visible = True
    Worksheets("Overlay").Visible = True
    Worksheets("HelpSheet").Visible = True
'
End Sub
```

Appendix H: Code Commentary

Data Conversion

The data conversion process is the most involved process of SMDC. It involves interaction between all three of the workbooks, SMDCBook, SMBook, and TargetBook. Additionally, there is both a data conversion process when standard units are used and one for when Metric units are used. These two processes are remarkably similar, only the Metric data conversion process involves converting the metric units to standard units.

3. Standard Data Conversion Process – Figure A2 is a flow chart describing the standard data conversion process. This figure fits into Figure 6A1 as the process labeled Standard Data Conversion. To better understand the variables used in Figure A2, Table 1 was provided. It contains a list of the variables used and what they represent. All of the "if statements" presented in Figure A2 were numbered to provide points of reference.

Table 1: List of Variables for Standard Conversion Process

| Variable	Description of Variable
R	Row Number in SMBook
RI	Bid Item Number on Previous Row
Trow	Row Number in TargetBook
SMQ	Quantity for Bid Item Entry in SMBook
TQ	Total Quantity (Present Sum of SMQ)
Counter	Bid Item Entry Counter (Represnets Number of Crew Days)
Result	Equals BI if BI is found in DBI, Equals #N/A (error) if not found
SMBook	IWR Being Converted
TargetBook	New File Being Created
DBI	List of Driving Bid Items for Selected Project Type
mo	Selected Estimate Month
yr	Selected Estimate Year
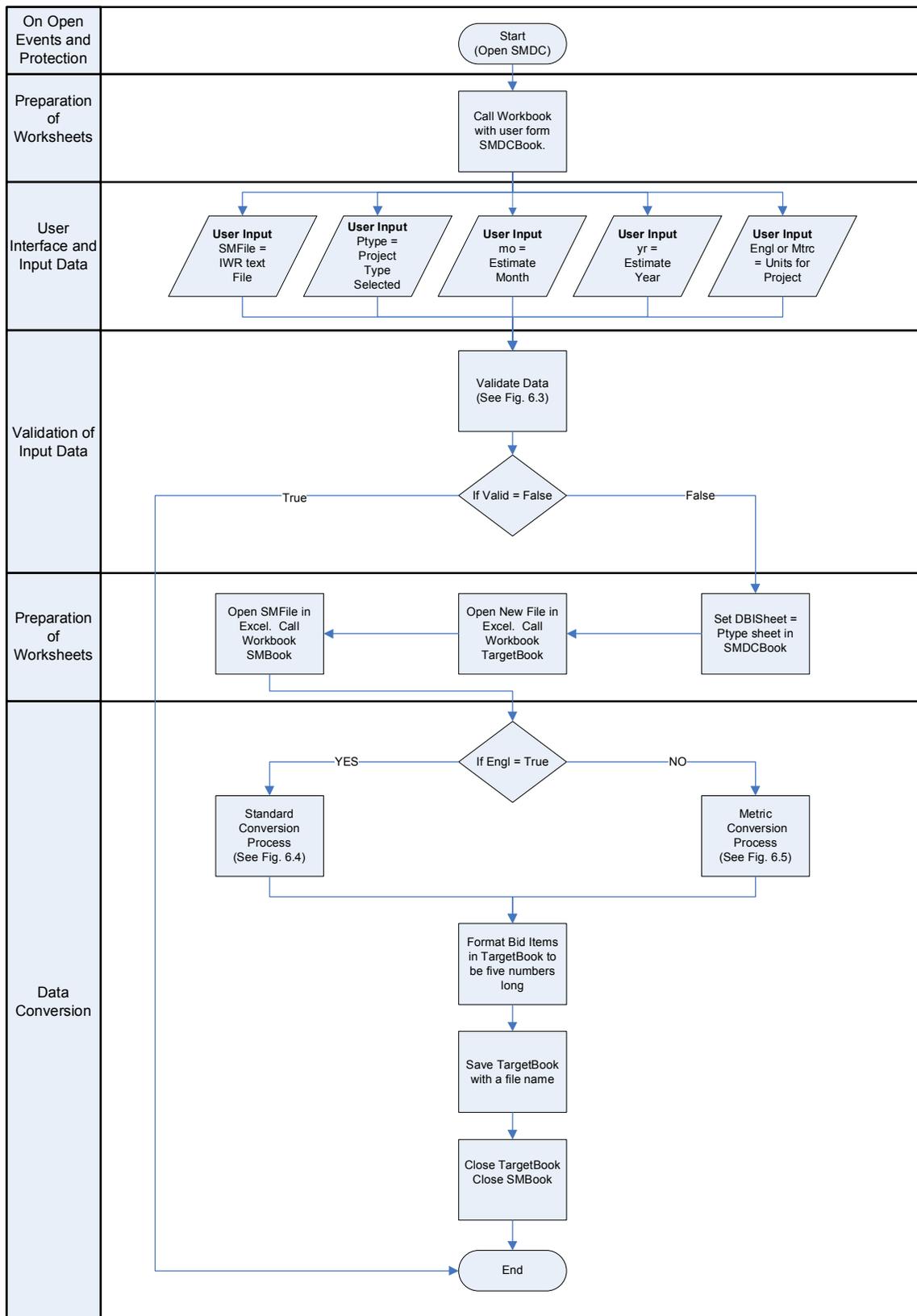
Figure A1: SMDC Flowchart

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The standard data conversion process begins with a set of data. R, the SMBook row number, is set equal to 2. This is because the first row in the IWR contains column headings and the actual data in the installed work report begins on row number 2. RI, the bid item number of the previous row, is set equal to 0. This is because when SMDC first runs and R = 2, there was no previous row containing actual data. RI is arbitrarily set to equal 0 because there is no bid item equal to zero. Trow, the TargetBook row number, is set to equal 1. This is because when data in entered into TargetBook, it is desired the data start on row number 1. SMQ, the bid item entry quantity, is set to equal 0. SMQ contains the value of the quantity placed on a bid item entry. When the program first runs there is no quantity so SMQ is arbitrarily set to equal 0.

The program then proceeds to if statement number 1. In the actual VBA code this is a while loop but in the flowchart it is presented as an if statement. This if statement checks value in the SMBook cell with a row number equal to R and a column number equal to 5 is a number. The cells in column 5 contain the bid item numbers in the IWR. If this value is a number, it is known that there is a bid item entry in this row. If an IWR text file is being converted then the first time if statement number 1 must make a decision, it will always be true. If a text file which is not an IWR was selected with the browse button, then if statement number 1 will most likely be false the first time it must make a decision and the data conversion process will end, converting no data into the TargetBook.

If the value in the SMBook cell with a row number equal to R and a column number equal to 5 is a number, then BI is set equal to this number. BI

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then contains the bid item number for the current row (row R). SMQ is set to equal the value in the SMBook cell with a row number equal to R and a column number equal to 7. The cells in column 7 contain the quantity placed for the bid item entries.

The program then proceeds to if statement number 2. This statement checks to see if BI = RI, or if the bid item number on the current row (row R) equals the bid item number on the previous row. The first time the program runs, BI will equal a bid item number and RI will equal 0 because there was no bid item number in the previous row. This if statement decision will be false the first time.

The program then proceeds to if statement number 3. This statement checks to se if RI > 0. In effect, this is checking to see if RI contains a bid item number. The first time the program runs, this if statement decision will be False because RI will equal 0.

The program then proceeds to set Counter = 1, because there is currently only one bid item entry with the current bid item number. TQ = SMQ because the total quantity at the present point is equal to the value of the quantity in the current bid item entry row. R is then incremented and set to equal R + 1 to check the next row in SMBook. Before moving the next row BI is set to equal RI because RI is equal to the bid item in the previous row and Result is set to equal the outcome of looking up RI (the bid item number of the previous row) in the DBI list. If RI is in the DBI list then Result = RI. If RI is not in the DBI list then Result = #N/A, an error. If statement number 3 will only be false the first time

the program runs. Every other time this statement must make a decision it will be true because RI will contain a bid item number rather than the number 0.

The program then proceeds back to if statement number 1 to check if there is a number in the next row (row number R). If there is no value in this cell, the data conversion process will end. If there is a number in this cell then BI is set to equal the value in the row R, column 5 and SMQ is set to equal the value in row R, column 7.

If statement number 2 then checks to see if BI is equal to RI. BI is the bid item number in the current row and RI is the bid item number in the previous row. If this statement is true, then R = R + 1 (the row number is incremented to the next row), Counter = Counter + 1 (to count the number of bid item entries with a bid item number equal to RI), and TQ = TQ + SMQ (the total quantity equals the previous total quantity plus the quantity in the current bid item entry row). The program would then move back to If Statement number 1 and follow this sequence until BI does not equal RI. At this point, if statement number 2 is false.

When if statement number 2 is false, BI does not equal RI. This means that the bid item on the current row is different than the sequence of bid items on the previous rows. At this point Counter will contain the sum of all the entries with bid item numbers equal to RI and TQ will contain the sum of the quantities for each one of these entries. When if statement number 2 is false, if statement number 3 is checked.

This statement checks if RI > 0 and will always be true except for the first time this statement must make a decision when RI = 0. When if statement

number 3 is true, if statement number 4 is checked. This statement checks if Result is an error. If Result is an error and if statement number 4 is true, then RI was not a driving bid item and it was not found in the DBI list. TQ is reset to equal SMQ (the quantity on the current row or the row containing the bid item number which did not equal RI) because a new sequence of bid items are being checked and the total quantity for this new sequence must be summed. Counter is reset to equal 1, because there is currently only one bid item entry which has been checked. R is set to equal R + 1, so that the next row of bid items can be checked. Also, RI is set to equal BI, because a new sequence of bid items is being checked. Result is also checked by looking up RI in the DBI list. If RI is present in this list, Result = RI. If it is not present in the list, Result = #N/A, an error. The program will then proceed back to If Statement number 1.

When If Statement number 4 is checked and it is false, Result equals a number rather than an error. This means that when RI was checked it was found in the DBI list and it is a driving bid item for the project type. The new file is then written according to the format shown in Table 4.1. In TargetBook, on row number Trow (first time the program runs Trow = 1) and column number 1, the value is set to equal the value in the cell of SMBook cell with row number 2 and column number 16 (cell with project number). Column number 2 is set to equal RI (the driving bid item number for the sequence of rows checked in SMBook). Column number 3 is set equal to the estimate month selected. Column number 4 is set equal to the estimate year selected. Column number 5 is set equal to TQ (the sum of the quantity of the sequence of entries with bid item numbers equal to

RI). Column number 6 is set equal to Counter (the sum of the number of entries with bid item numbers equal to RI).

Start Standard Data Conversion Process

R = 2
RI = 0
Trow = 1
SMQ = 0
SMBook
TargetBook
DBI
mo
yr

1.
If value in SMBook Cell Row = R Column = 5 is a number — **False** → **End**

True

BI = Value in SMBook Cell Row = R Column = 5

SMQ = Value in SMBook Cell Row = R Column = 7

2.
If BI = RI — **False** → **3.** IF RI > 0 — **True** → **4.** If Result = Error

True

R = R + 1
Counter = 1 + Counter
TQ = TQ + SMQ

3. False →
Counter = 1
TQ = SMQ
R = R + 1
RI = BI
→ Result = Lookup BI in DBI

4. False →
Set TargetBook Cell Value in Row = Trow, Column = 1 equal to SMBook Cell Value Row = 2, Column = 16

Set TargetBook Cell Value in Row = Trow, Column = 2 equal to RI

Set TargetBook Cell Value in Row = Trow, Column = 3 equal to mo

Set TargetBook Cell Value in Row = Trow, Column = 4 equal to yr

4. True →
TQ = SMQ
Counter = 1
R = R+1
RI = BI
→ Result = Lookup BI in DBI

Set TargetBook Cell Value in Row = Trow, Column = 5 equal to TQ

Set TargetBook Cell Value in Row = Trow, Column = 6 equal to Counter

TQ = SMQ
Counter = 1
R = R + 1
RI = BI
Trow = Trow + 1

Result = Lookup BI in DBI

Figure A2: Standard Data Conversion Process

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2. Metric Data Conversion Process – the Metric data conversion process is exactly the same as the standard data conversion process with one exception. When data is being recorded to TargetBook (the file being created which is readable by BIDDS), rather than setting the values in column number 5 equal to TQ Column (the sum of the quantity of the sequence of entries with bid item numbers equal to RI which was checked) it is set equal to TQ * Conv. Conv is the conversion factor from Metric to standard for the driving bid item (RI). It is found on DBIBook column number 6 as can be seen in Table 6.1. The metric conversion process is presented in Figure A3.
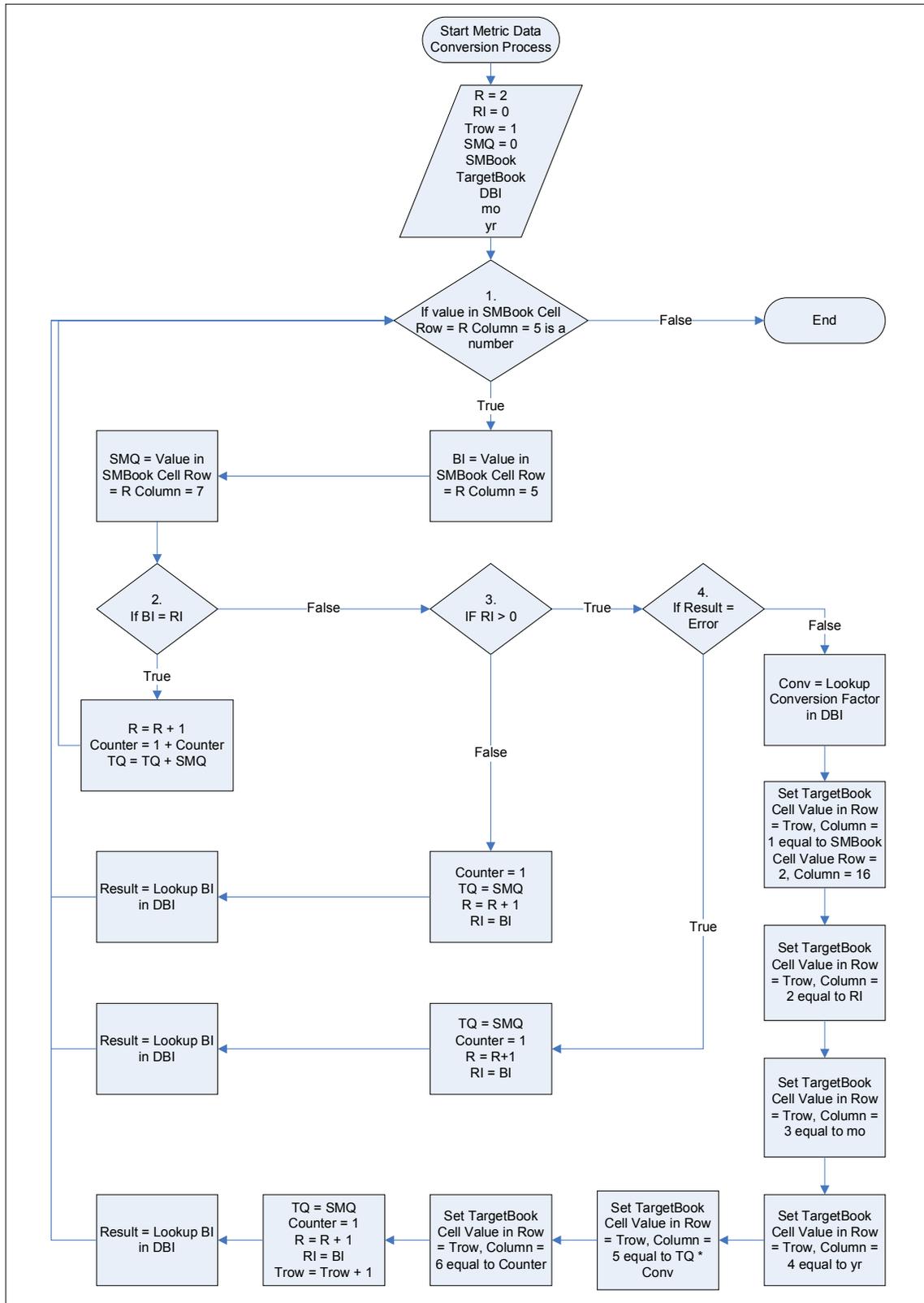
Figure A3: Metric Data Conversion Process

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Appendix I: Help File Contents

What is *SiteManager* Data Converter?	*SiteManager* Data Converter is a program which converts an Installed Work Report (IWR) exported from *SiteManager* into a file readable by the Bid Item Duration Database System.
How do I export an IWR from *SiteManager*?	To export an Installed Work Report (IWR) from *SiteManager*: 1. Click on the Contractor Payments tab on the *SiteManager* Main Panel 2. Click on reports 3. Click on Installed Work 4. Select the Contract ID for the project you wish to generate an IWR and click OK 5. Click on Services on the menu bar 6. Click Export 7. Select the location on your computer you wish to save the IWR and name the file 8. Select save file as text file (*.txt) and click OK
How do I select an IWR to convert?	To select an Installed Work Report (IWR) to convert into a file readable by the Bid Item Duration Database System: 1. Generate an IWR in *SiteManager* and export the report (See: How do I export an IWR from *SiteManager*?) 2. Click on Browse from the *SiteManager* Data Converter screen 3. Select the location on your computer the IWR was saved 4. Select the name of the IWR you wish to convert 5. Click OK 6. The file name and path should appear in the box to the left of the Browse Button
What is my project type?	It is very IMPORTANT that the project type you select is the same project type on record in the Bid Item Duration Database System (BIDDS). If you do not know what project type is on record in BIDDS then you need to contact the person who initialized the project inside BIDDS and obtain that information. If the project has not yet been initialized inside BIDDS then you can select a project type which is applicable to your project within *SiteManager* Data Converter and use the same project type when initializing the project in BIDDS. For suggestions on project types see Project Type.

What estimate month should I select?	Select the estimate month for which the installed work report represents. The estimate month is the month the estimate was generated.
What estimate year should I select?	Select the estimate year for which the installed work report represents. The estimate year is the year the estimate was generated.
What are my projects units?	Your project's units are the units of measurement being used on the project. This information can be found in the project's contract. If metric units are selected then the new file created will contain quantities converted from metric units to standard units.
How do I convert an IWR file?	To convert an Installed Work Report text file into a file readable by the Bid Item Duration Database System (BIDDS): 1. Click Browse and select the file you wish to convert 2. Select your project type 3. Select your estimate month and estimate year 4. Select the units of measurement used on the project 5. Click Continue 6. Name the new file and select the location on your computer to save the new file
Project Type - New Road Construction	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.
Project Type - New Bridge Construction	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.
Project Type - Road Reconstruction	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.
Project Type - Bridge Reconstruction	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.

Project Type - Road Rehabilitation	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.
Project Type - Bridge Rehabilitation	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.
Project Type - Widening	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.
Project Type - Overlay / Resurfacing	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.

Appendix J: Joseph Bouchey's Comments Regarding the Recommendations

The following, in italics are Joseph Bouchey's comments in reference to the recommendations presented in Chapter 10. Joseph Bouchey is an information technology specialist with VDOT and works primarily with *SiteManager*. A response was prepared and follows each comment.

In reference to Recommendation 2.01 to modify the *SiteManager* system to distinguish the list of DBIs by bolding the bid item text or filling the background with a different color, Joseph Bouchey offered the following comment:

Creating a DBI indicator is very complicated and potentially dangerous from an application development prospective. As you are aware, SiteManager (SM) is an application that we license and the code has only limited ability to be customized. However, if VDOT elects to pursue capturing production rate data, we do have the means to make modifications as you suggest to the application, but if the code becomes corrupt for any reason, the application warranty will become invalidated. The modification will also create a continuous maintenance issue as with every subsequent release (product update by AASHTO) is distributed; a re-engineering of the source code must be done to incorporate VDOT's customizations. Coincidently I am working on a "Plug-in Concept" where generic fields may be assigned at an Item level which will allow several descriptive fields with various field types ie. Indictor, number, short and long string, and date fields. The intent is to use these fields for things such as "Activity" code purposes.

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Although this comment was in reference to Recommendation 2.01, the limitations presented apply to all the recommendations requiring the *SiteManager* system to be modified. According to Mr. Bouchey, VDOT has a limited ability to modify the source code without risking the loss of an application warranty. VDOT can, however, modify the source code if they choose. By doing so, AASHTO does not warranty the source code should it may become corrupt. In addition, each subsequent version of *SiteManager* released by AASHTO will not include any modifications made by VDOT and VDOT will have to continue to modify each release. This would cause a continuing maintenance problem. If AASHTO would modify the *SiteManager* source code, VDOT would not have to risk losing the application warranty provided for the software by making the modifications themselves and would not have any maintenance problems associated with modifying each subsequent release of *SiteManager*. For this reason, it is recommended that VDOT consult with other states using *SiteManager*, share with them the benefits of these modifications, build consensus that the modifications need to be made, and request AASHTO to make the modifications to the source code. Until this is done, the generic fields created by the "Plug in Concept" being developed by Mr. Bouchey may be able to be used to distinguish the DBIs from the non-DBIs.

In reference to collecting the number of crews used to perform the work on a DBI for each day, Mr. Bouchey stated:

Determining the number of crews could have been done by identifying locations. SM has the capability of capturing work location (sequence numbered) with a unique

reported quantity for each location number. The inspector would simply enter a new location with associated details for each crew.

This is essentially the same as Recommendation 5.01 which modifies the methods of *SiteManager* use by requiring project personnel to record the resulting daily quantity installed by each crew for a DBI even if the quantity is zero. Each entry is counted as an active crew day. With each entry, the project personnel have the ability to specify the location the work is being performed and therefore the location of the crew.

In reference to resolving the issues with collecting performance time data for lump sum DBIs, Mr. Bouchey suggested the following:

One suggestion would be to; at the start of each contract determine which lump sum (LS) items are DBIs and delete them through a change order. Add the items back in but switch the bid quantity with bid price, thus giving a tangible quantity to work with. Example: Concrete Curbing: qty 1, price $15,000. Replace it with qty 15,000 price $1.00. Unit type should be Hr vs LS. Although this might be a bad example, perhaps you could evaluate the concept using a better example.

The only time there are issues with collecting performance time data for lump sum DBIs are when only the methods of *SiteManager* use are modified and active crew days are collected by making a work item entry for each crew working on each DBI. It is standard practice to enter the percent complete for lump sum items on the day the estimate is being performed. This may not be a day the contractor worked on the DBI. By entering the percentage complete quantity on a day the contractor did not work, the number of quantity entries will not correspond with the number of crew days. If the

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SiteManager system is modified, there will not be any issues with collecting performance time data for lump sum items. Mr. Bouchey presents a valid way to overcome this issue. It will, however, create a constant need for issuing change orders after contracts are awarded. One reason VDOT uses lump sum items is to reduce the risk of specifying a quantity. By issuing a change order, VDOT may be assuming risk associated with specifying a quantity.

In reference to the possible need for project personnel to withhold payment until a later date and making the work item entry to pay the contractor during a day when no work was performed on the DBI, Joseph Bouchey offered the following comments:

Issues with making payments for corrective work or payments when no physical work is being done can be done by extracting only those reported quantities on DWRs with contractor labor and equipment present. Another option would be, where inspection staffing levels permit, assign one inspector the responsibility for entering quantities that will not count toward production levels and discount the quantities associated.

When collecting performance time data, the total quantity needs to be collected and no quantity needs to be discounted from the total quantity. The active crew day collected by making a work item entry during a day when no work was performed needs to be discounted from the count of active crew days. This could be done, as Mr. Bouchey suggests, by counting only the days when contractor labor and equipment are present.

In reference to extracting performance time data from *SiteManager*, Mr. Bouchey stated the following:

SiteManager resides on two servers (one for the application itself and one for the database). The database is on Oracle(r) and can be connected to through an ODBC connection thus allowing for easy extraction of data in any format needed. One suggestion to be considered is directly connecting to BIDDS rather then having a manual import and export. Much can be done regarding querying the data if the selection set for the data is known.

Recommendation 6.03, investigate linking BIDDS to *SiteManager* data tables, is a recommendation that VDOT explore the possibility of directly connecting BIDDS to the Oracle® database which houses the data collected by *SiteManager*.

In reference to training inspectors to collect performance time data, Mr. Bouchey presented the following comments:

Training inspectors on recording zero items would not be a concern, but it could significantly increase their time spent using SM. However, there are significant advantages to recording zero quantities that go beyond production rate collection. The ability to tie subcontractors and the prime to daily activity (items performed) will help with researching claims or justifying time extensions.

It is believed that the additional time required to collect performance time data was a consideration during this research and collecting performance time data will not significantly increase the time project personnel spend using *SiteManager*. As Mr. Bouchey states, there are more advantages to recording zero quantity entries than those discussed during this research. It can help to develop as-build schedules, track when certain work was performed as well as researching claims and justifying time extensions.

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Training inspectors on what is a DBI's and how it is to be tracked may prove to be more of an effort. To convince the inspector on what benefit it would have for him to know production rates may prove to be a tuff sell as with anything else, their must be a "cost vs. benefit" ratio in his/her favor. Not every project is a good candidate for DBI methodology.

Hopefully, if requested by the Partnership and directed by VDOT, the project personnel will not have to be sold on the idea of collecting performance time data. The ability to use the data for other purposes such as researching claims and justifying time extensions may be the benefit the project personnel consider to be the greatest.

Mr. Bouchey offered additional suggestions in the following comments:

Type of contract and or project must be considered when evaluating production rates. SM captures this data, but this data must be analyzed carefully as more then one project type can be assigned to a contract which makes it difficult to parse out which items are to be grouped. Also, perhaps VDOT could redefine projects types to better capture the nature of the work.

These comments stretch outside the scope of this research, but type of contract and type of project are considerations being made by the Partnership. The Partnership has defined eight project types which describe common VDOT projects. When there is more than one project per contract, each project, identifiable by its unique project number, is assigned a project type. The DBIs are then identified for each project depending on the type of project being performed. VDOT may wish to consider

redefining their project types to align with the project types being used by the Partnership.