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RECONSTRUCTION OF US-231 BETWEEN BOWLING GREEN AND SCOTTSVILLE, KY

Project Item No.
3-146.00

VALUE ENGINEERING STUDY FINAL REPORT

March 26, 1997

RECONSTRUCTION OF US-231
BETWEEN BOWLING GREEN AND SCOTTSVILLE, KENTUCKY

Project Item Number
3-146.00

VALUE ENGINEERING STUDY
for
Kentucky Transportation Cabinet

Study Date: March 17 - 20, 1997

Final Report

March 26, 1997

Dames & Moore
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Acknowledgments
A thank you is given to the staff members from the Kentucky Transportation Cabinet. A special thanks is also extended to Daryl Greer and Kenneth Cox of the Cabinet for their able assistance. This VE Study has been successful because of the dedication of the participants.

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EXECUTIVE SUMMARY

This report documents the results of a value engineering study on the Reconstruction of US-231 between Bowling Green, KY and Scottsville, KY. The study workshop was conducted at the Kentucky Transportation Cabinet District 3 Office located in Bowling Green, KY on March 17 - 20, 1997. The project consists of five sections, and at the time of the study, all were at varying stages of design (15%, 15%, 30%, 30%, 90%). The value engineering study team was from the firm of Dames & Moore Group and the Kentucky Transportation Cabinet, and was facilitated by a CVS team leader from Dames & Moore. The project design is divided between Presnell Associates in Louisville, KY, and the Kentucky Transportation Cabinet in Bowling Green. One project section is designed by Presnell, the other four by the Cabinet. The project manager for Presnell is Glen Kelly. The project manager for the Cabinet is K. W. Cox. An oral presentation of the study results was made to K. W. Cox from the Cabinet on Thursday 20 March at 2:00 pm in the workshop room.

The study team found no failure in the design as received. On the contrary, the design as given to the team proved workable in every way. Very few recommendations of any significance were developed. The opinion of the team is that the project design at this point is well thought out.

In a case where few recommendations are presented, the worth of the value study rests more with the validation of the proposed design. This provides the owner with the added security in knowing that an independent body of professionals has studied the project to date, and has come up with findings similar to that of the design team. Such a study report on the shelf gives the design additional credibility against those who might later criticize design decisions.

The Job Plan.
The study followed a five step job plan endorsed by S.A.V.E. International, the professional organization of value engineers in the United States.

The Project.
The project can be briefly described as follows. The existing US-231 between Bowling Green and Scottsville is substandard in many ways, e.g. roadway section, horizontal and vertical alignment, safety, and drainage. This project will remedy all deficiencies, and will continue the upgraded roadway section already in place to the north of Bowling Green.

Recommendations.
Recommendations for change to the design are put forth in this report. These recommendations represent, in the opinion of the study team, changes that will improve the overall project. The value study team however has no authority to impose change, but simply is making recommendations. The final decision as to implementation of the recommendations noted, will rest with the project owner in consultation with the project design team.

Savings From Recommendations.
At the time of the study, there was no current estimate of total project cost for all five sections. The VE team estimated an approximate total cost of the project at $46,716,289. The study generated 31 ideas, of which 5 were developed as recommendations to be submitted for consideration by the owner and design team. One recommendation involved an added life cycle cost of $615,138 and 4 recommendations involved a reduction in life cycle cost of $236,819. All recommendations cannot be accepted together as some are mutually exclusive of others. The value team developed a suggested list of what was, in their opinion, the best mix of recommendations for the overall good of the project, considering both cost savings and value added. If this list of recommendations were to be accepted, the project would realize an added first cost of $99,943 with a total potential life cycle savings of $147,947. The complete documentation of all recommendations is included in Section 3. A summary of all recommendations can be found in Section 3, in the table titled *Summary of Recommendations.*

Design Suggestions.
Some ideas that did not make the selection for development as recommendations, were, never-the-less, judged to be worth further consideration. These ideas have been written up as "Design Suggestions" for review by the owner and design team. Documentation of all design suggestions can be found in Section 4.

Validated Items.
Significant parts of the project that were selected for study did not result in any legitimate ideas, recommendations, or design suggestions for improvement. If a part of the design studied by the team did not result in any suggestion for change, then that part of the design can be accepted as having been validated by the team, and has been so noted.

Since certain parts of the design have been validated by an outside team of professionals this, can serve as additional justification for the design decisions thus made. Raises the owner's level of confidence in the direction the project is taking. Documentation of all validated items can be found in Section 5.

Cost Estimate.
The current estimate of construction cost was used as a base line for study. For the study to be valid, the base line estimate must be reasonably accurate. For this reason, the team reviewed the estimate to make sure there was general acceptance and agreement as to accuracy. As a result of this review, the following conclusions were made:

There are four cost estimates at present; an early planning estimate made by Wilbur Smith and Associates, and three designer's estimates for each of three of the five construction sections. In the opinion of the team, the early planning estimate is low by $18.8 million. This variation can be explained. More information is now available, plus the alignment has been adjusted to try for earthwork balance in each of the five construction sections. The planning alignment, on the other hand, was balanced for the total project. The team has estimated the total cost to the owner of

the complete project at $46,716,289.

Summary of Recommendations.
A summary of the recommendations of this study will be found in Section 3 in the Summary of Recommendations. The recommendations are listed, along with the economic impact of each, in terms of savings or added cost. The column titled "Suggested Best Selection" marks the specific mix of recommendations deemed by the team as being the best choices to be made (the team's suggested choices) considering the effect of both savings and added quality on the overall project.

At the end of this report, in Appendix G, there is a Response to Recommendations Decision Worksheet which is provided to be used in the approval process. For this project the designer is Presnell Associates in Louisville and the Kentucky Transportation Cabinet. The owner is the Kentucky Transportation Cabinet.

SECTION 1 - INTRODUCTION

This report documents the results of a value engineering study on The Reconstruction of US-231 between Bowling Green, KY and Scottsville, KY held in Bowling Green on March 17 - 20, 1997. The study team was from the firm of Dames & Moore and the Kentucky Transportation Cabinet, the names of which are listed in the Appendix. Other participants of the study (other than the study team) are also listed in the Appendix.

Boundary of the Study
The scope of the study as given to the team was as follows:
Study within the existing corridor.

Study Constraints Given to the Team Were:
Major changes in horizontal alignment that would move the roadway out of proposed corridor were not considered unless a major improvement could be expected. This would set the project back in terms of years because new public hearings and a new environmental study would then be required.

Study Objective
The study goals given to the team were:

To verify the design
To find improvements in the design

Ideas and Recommendations
Part of the value methodology is to generate as many ideas as practical, and to then evaluate the ideas and select those that offer quality improvement as candidates for further development. If the ideas thus selected, turn out to work in the manner expected, they are then put forth as formal recommendations. Only those ideas that are proven to the team's satisfaction are listed as recommendations. Each idea generated is given a unique identification number that remains with that idea throughout the study. If an idea graduates to the status of recommendation, the recommendation carries with it the same unique identification number as did the idea from which it came.

Organization of This Report
This report is divided into 8 sections, which are described below.

SECTION ES - EXECUTIVE SUMMARY: The Executive Summary is a short overview of the significant and important parts of the report.

SECTION 1 - INTRODUCTION: This section familiarizes the reader with the contents and organization of the report, and with certain significant aspects of the study.

SECTION 2 - PROJECT DESCRIPTION: The Project Description orients the reader to the project under study. The Project Description documents the project as it was presented to the team at the beginning of the study. It also brings the reader up to date through project background information, relevant politics, and an outline of the intended steps in the project.

SECTION 3 - RECOMMENDATIONS: The Recommendations Section forms the heart of the report, documenting the complete writeups of all recommendations put forth by the study team. The Recommendations Section includes a table titled *Summary of Recommendations* that summarizes all recommendations in one document.

SECTION 4 - DESIGN SUGGESTIONS: The Design Suggestions Section documents those ideas that were deemed worth further consideration by the team; but were, for certain reasons, not presented as formal recommendations in Section 3.

SECTION 5 - VALIDATED ITEMS. These are items, that after an independent review, suggest no apparent means for improvement. They are recorded in the report for the benefit of the reader.

SECTION 6 - IMPLEMENTATION: The Implementation Section documents the final decisions regarding acceptance or rejection of recommendations and design suggestions. Once a recommendation or design suggestion is accepted, it is ready to be implemented into the design. The final decision regarding implementation of a recommendation is the ultimate outcome of the study.

APPENDICES - The Appendices contain backup information to the main body of the report.

SECTION 2 - PROJECT DESCRIPTION

The project as presented to the team at the beginning of the study was as follows.

The project consists of the reconstruction of US-231 between Bowling Green, Kentucky and Scottsville, Kentucky. The highway as it exists now is a two lane paved road with numerous turns and hills. It is a typical ridge road that twists and turns as it runs up and down hill. There are two bridges spanning Drake's Creek, one over the main channel, and a second shorter bridge across the overflow channel. A small portion of the roadway is an urban section coming out of the south part of Bowling Green. The remainder, and major portion, of the roadway is a rural section extending south to Scottsville.

With the numerous curves and hills on a two lane rural roadway, it is almost impossible to find a suitable place to pass. Added truck traffic has added to the problem. Accidents reinforce the need to reconstruct the road.

In 1993, Wilbur Smith and Associates did a corridor study that documented these same problems. Several alternate routes were studied, public hearings were held, and approval was obtained from the Federal Highway Administration (FHWA). As a result of preliminary research, it was determined that the alignment now proposed in the current design would have no impact upon the community.

The overall project is defined by the number 146. The construction sections are designated as numerical subsets of 146 (146.01, 146.10, 146.20, 146.30, and 146.40) The project begins at Bowling Green, KY and continues to Scottsville, KY. The construction section numbering sequence does not follow the geographical sequence of the sections.

The following table shows the relationship of numbers and geographical sequence, as well as other assorted general data.

The Reconstruction of US-231 between Bowling Green and Scottsville, KY GENERAL DATA							
total project length = 28.48 km (17.7 mi)							
Construction Section Number	146.01	146.20	146.30	146.40	146.10		
Estimate exists	YES $3,994,719	YES $11,098,154	NO	NO	YES $12,790,477		
Budget	$5,000,000	$11,000,000	$7,750,000	None	$12,000,000		
Length of each section	2.707 km (1.65 mi)	5.793 km (3.75 mi)			7.18 km (4.2 mi)		
Section	URBAN	RURAL	RURAL	RURAL	RURAL	URBAN for ½ mile.	
Design Stage	90% Design	30% Design	15% Design	15% Design	30% Design		
Bowling Green, KY							Scottsville, KY

US-231 coming into Bowling Green from the north is a 5-lane roadway. Going out of Bowling Green to the south, US-231 is 2-lanes. This project will upgrade the road south out of Bowling Green to 5-lane urban section while in town. Once out of town the section will then transition to a 4-lane divided rural section. The 4-lane divided roadway will continue on south to Scottsville. The 4-lane roadway will be partially controlled and will have a 12 meter (40 foot) depressed median. The typical sections are shown later in this section.

Traffic counts are 3,000 to 4,000 Average Daily Traffic (ADT). In 2013 this traffic is predicted to be between 5,000 to 23,000 ADT, depending upon location. The traffic count does not take into account the extension of the William Natcher Parkway in Bowling Green. This will bring added development into the US-231 corridor over and above that predicted.

Several characteristics of the existing roadway have driven this project, causing the project to (1) come into being, and (2) direct the proposed design as it now exists. Below are listed several characteristics of the corridor that have posed unique design requirements on the project.

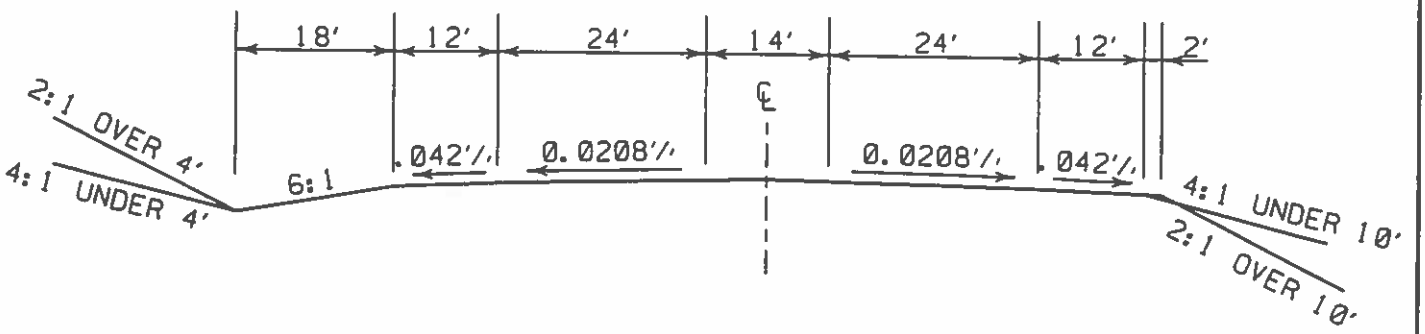
General characteristics of US-231

1. The horizontal alignment with many sharp curves, and limited sight distances.
2. The vertical alignment with many hills, and limited sight distances.
3. An inadequate typical section of 2-lanes, with inadequate lane and shoulder width.

Characteristic : of the geography of the area have a"ected the proposed design.

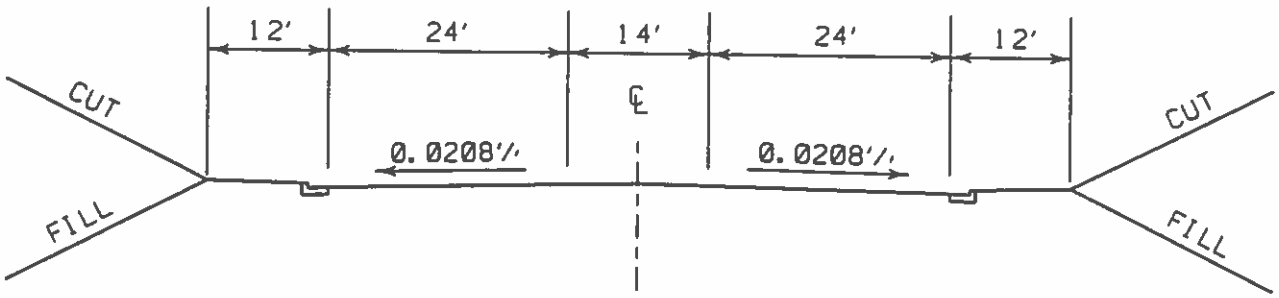
1. Past increases and future projected increases in traffic (especially trucks)
2. Accidents
3. Sink holes
4. Land use - expensive development, and subdivisions along the corridor.
5. Wetlands
6. Existing utilities locations
7. Archeological sites
8. Sites proposed for the historical register
9. Bat caves
10. Connecting roads

The proposed project responds to all of the above determinants. The intent is to greatly improve the highway conditions on US-231 between Bowling Green and Scottsville.



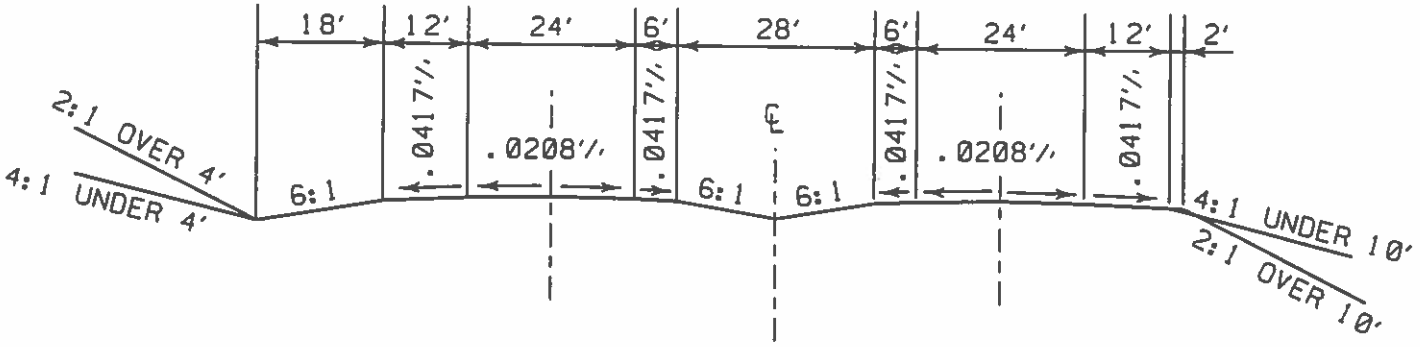
URBAN TYPICAL SECTION

5 - LANE SECTION



URBAN TYPICAL SECTION

STANDARD CURB & GUTTER



RURAL TYPICAL SECTION

DEPRESSED MEDIAN

~NOTES~

KENTUCKY

TRANSPORTATION CABINET

DEPARTMENT OF HIGHWAYS

U.S. 231 TYPICAL SECTIONS

BOWLING GREEN - SCOTTSVILLE RD.

WARREN - ALLEN COUNTY OF:

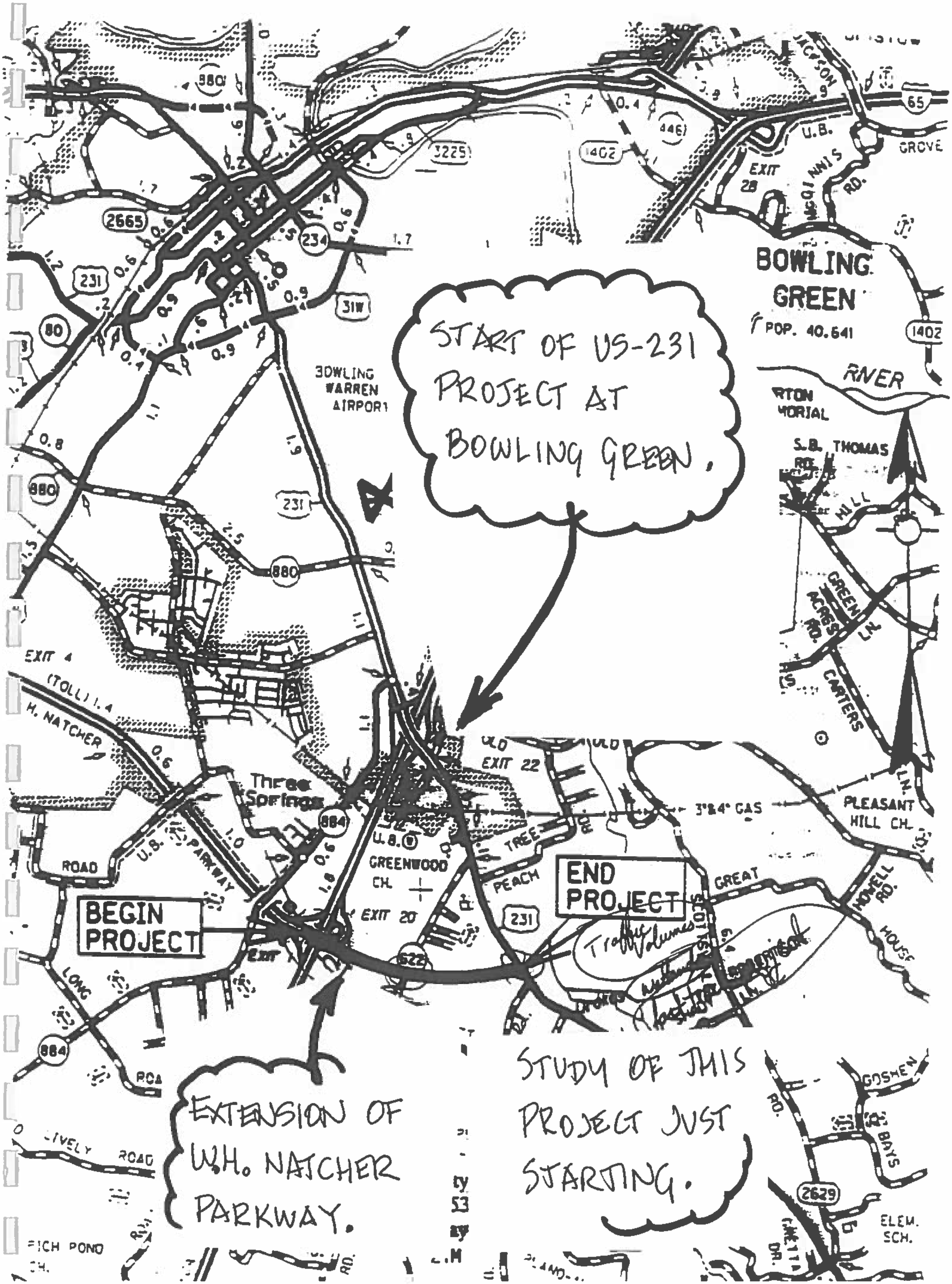
KENTUCKY STATE OF:

DRAWN BY: R.L.W.

1 of 2 SHEET NO.:

DATE: mo. 11 /yr. 92

ILBUR ASSOC EXING


START OF US-231
PROJECT AT
BOWLING GREEN.
BEGIN
PROJECT
END
PROJECT
EXTENSION OF
W.H. NATCHER
PARKWAY.
STUDY OF THIS
PROJECT JUST
STARTING.
BOWLING
GREEN
POP. 40.641
BOWLING
WARREN
AIRPORT
Three
Springs
GREENWOOD
CH.
EXIT 20
EXIT 22
EXIT 28
EXIT 4
(TOLL) 1.4
H. NATCHER
PARKWAY
RIVER
S.B. THOMAS
RD.
GREEN
ACRES
RD.
CARTERS
PLEASANT
HILL CH.
3"&4" GAS
GROVE
GOSHEN
BAYS
ELEM.
SCH.
LIVELY
ROAD
PEACH
TREE
GREAT
HOWELL
RD.
Traffic Volumes

SECTION 3 - RECOMMENDATIONS

This section contains the complete team writeups of all recommendations to come out of this study. Each "recommendation" is marked by a unique identification number. This is the same identification number that is found attached to the "idea" from which the recommendation was developed. These identification numbers are used throughout the report to uniquely refer to a given recommendation and corresponding idea.

Acceptance of Single Issues
Each recommendation is developed around a single issue. This simplifies the acceptance or rejection of the recommendation, and gives added flexibility to the implementation of the recommendations, in that several single issue recommendations can be combined as needed to achieve a desired result. When evaluating a recommendation, each part of the recommendation should be reviewed on an independent basis. There is no need to discard a recommendation in total because one part of the recommendation is unacceptable.. A recommendation can be accepted in part, or accepted with a specified partial modification.

Usually all recommendations cannot be simultaneously accepted or combined. This is because some recommendations are mutually exclusive of one another, and the acceptance of one recommendation will automatically preclude the acceptance of certain others.

Summary of Recommendations.
The reader will find a table titled *Summary of Recommendations* at the beginning of the recommendation writeups.. This table offers a convenient overview of all recommendations along with economic data associated with each. As mentioned above, all recommendations cannot be accepted together. For this reason, the reader is cautioned with regard to adding up the column of monetary savings. Since some recommendations are mutually exclusive of others, the addition of all monetary savings to form a sum total of savings will produce a fictitious and erroneous amount..

The team did develop what is, in the opinion of the team, an optimum mix selection of recommendations, that are the team's suggestion for combining recommendations. This "optimum selection" will, in the opinion of the study team, provide maximum overall benefit to the project. These recommendations are keyed in the column *suggested best selection.* The recommendations so keyed can be accepted together and the corresponding monetary savings can be added. This will give the reader a reasonable estimate of the maximum potential savings that can be realized from this study. For this study this total savings is found to be $147,947 in potential life cycle savings.

Organization of Recommendations.
The recommendations presented on the following pages are organized alphabetically by function identifier, and numerically within each function.

The sequence of functions are as follows:

B = Bridge Recommendations

D = Drainage Recommendations

P = Pipe Recommendations

S =Structural Recommendations

SH = Sink Hole

FORM 30 DEC 19th

TABLE 3-1. SUMMARY OF RECOMMENDATIONS

Project: U.S. 231
Location: Bowling Green to Scottsville Road
Study Date: March 17-21, 1997

DESCRIPTION		PRESENT WORTH AMOUNT					BEST
I.D. #	Recommendation	1st cost of original design	1st cost of recommen-dation	resulting 1st cost savings (or cost)	O & M savings (or cost)	total LCC savings (or cost)	suggest-ed best selection
B-4	From Dye Ford Road To South of Drakes Creek Bridge. The Roadway section will be an urban 5-lane section with shoulders.	4,459,972	4,371,100	88,872	0	88,872	
B-4A	Same as B-4 with the addition of a median barrier.	4,459,972	5,075,110	615,138	0	615,138	
D-1	Eliminate Culvert Head walls.	20,891	13,770	7,121	0	7,121	X
P-1	Add perforated pipe in curb and gutter section for drainage purposes.	480,761	596,917	(116,156)	247,890	131,734	X
S-1	Modular Block Retaining Wall at Greenwood High School.	19,388	10,296	9,092	0	9,092	X

LEGEND: LCC = life cycle cost = 1st cost + all use-costs over the life of the project.
LCC savings = 1st cost savings (or adds) + all O & M cost savings (or adds) over the life of the project.
Note: savings in parenthesis "( )" = negative savings = added cost.

VALUE ENGINEERING RECOMMENDATION

FORM 20 DEC 1996

PROJECT U.S. 231
LOCATION: Bowling Green to Scottsville Road
STUDY DATE: March 17-21, 1997

IDENTIFICATION NUMBER: B-4
FUNCTION OF COMPONENT BEING CHANGED: General Project
DESCRIPTIVE TITLE OF RECOMMENDATION: From Dye Ford Road to South of Drakes Creek Bridge, the roadway section will be an urban 5-lane section with shoulders.

ORIGINAL DESIGN:

North of Dye Ford Road, the roadway section is a 5-lane urban section including curb & gutter, sidewalk, and storm drainage collection. From Dye Ford Road to about 0.4 mile north of US 31E the roadway section is a 4-lane rural section with a depressed 40-foot median and a minimum 1200-foot spacing of access points. There will be two, 2-lane bridges in each direction, one crossing Drake's Creek and one crossing the Drake's Creek backwater area with a bridge width of 42.0 ft.

RECOMMENDED CHANGE:

It is recommended that a new 5-lane urban roadway section with shoulders will connect to the presently designed 5-lane urban roadway with curb and gutters at Dye Ford Road and extend to the south for approximately 2.6 kilometers (1.6 miles). The 5-lane urban section north of Dye Ford Road includes curb and gutter, sidewalk and storm drain collect system. The recommended new 5-lane urban section continuing south from Dye Ford Road will include 12-foot wide outside shoulders in lieu of curb an gutter. The new section will extend from Dye ford Road to station 14 + 200 (approximately) 200 meters south of Duke's Bridge.

SUMMARY OF COST ANALYSIS			
	First Cost	O & M Costs (Present Worth)	Total LC Cost (Present Worth)
ORIGINAL DESIGN	4,459,972	0	4,459,972
RECOMMENDED DESIGN	4,371,100	0	4,371,100
ESTIMATED SAVINGS OR (COST)	88,872	0	88,872

VALUE ENGINEERING RECOMMENDATION

IDENTIFICATION NUMBER: B-4 Page 2 of

The roadway section will include two 3.3 meter driving lanes and a 3.3 meter outside shoulders in each direction. The new roadway segment will have a 1200-foot minimum between access points. A paved median will be 4.2 meters (14 feet) wide. The new roadway section will extend across the Drake's Creek flood plain requiring 2 26-meter (84-foot) wide bridges (one bridge over Drake's Creek and one over Drake's Creek backwater area) in lieu of the 4 bridges required in the original design.

ADVANTAGES:

- A savings will be realized with the reduction of the embankment fill where the roadway crosses the flood plain of Drake's Creek.

- A savings will be realized with one 5-lane wide bridge crossing Drake's Creek and one crossing the backwater area as apposed to having 4 bridges as required in the regional design.

- A reduction of the required right of way width of about 7.9 meters (26 feet) will result by decreasing the median width. There will be a significant reduction of the impact on the adjacent property owners.

- A reduction of the right of way width will reduce the impact to the archeological site located immediately to the north of Drakes Creek.

- A continuity of the 5-lane urban section extending from the beginning of the project near I-65 to Station 14 + 200 (approximately 200 meters south of Drakes Creek Bridge) is consistent with the expected urban growth in the existing urban development immediately south of I-65 As urban development expands to the south, partial controlled access roadway section can be changed to access by permit when it becomes required.

- A shortened construction schedule will be realized.

DISADVANTAGES:

- The roadway section with a 4.2-meter (14 foot) paved median will be less esthetiallly pleasing that the wider depressed 12-meter (40-foot) median.

- By reducing the 12-meter (40-foot) wide depressed median to a 4.2 meter (14 foot) wide paved median on-coming traffic will be closer together, as such:

- There will be an increase of vehicle operator anxiety and decrease in comfort.
- Headlight glare will be increased.
- A 4.2 meter (14 foot) wide median will have a higher potential for head on collisions. A 40-foot depressed median will virtually eliminate the potential for head on collisions.

JUSTIFICATION:

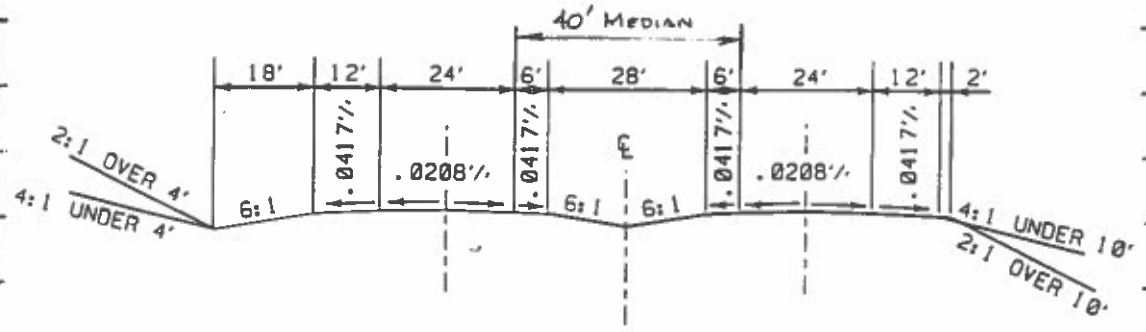
- By reducing the median width of the 40-foot wide depressed median to the paved 14-foot wide paved median the advantages outweigh the disadvantages.
- The extension of the urban roadway section past Drake's Creek is compatible with the predicted urbanization growth extending to the south from the northern end of the project limits.
- .The 5-lane urban roadway section would be an extension of the presently designed 5-lane urban section. The proposed section would not be an isolated section of roadway within 14-mile long, 4-lane, 40-foot wide depressed median roadway section of the project.
- The 5-lane urban roadway section facilitates the design of one bridge crossing the Drake's Creek and one bridge crossing the backwater area as apposed to two bridges required for each direction of traffic.

VALUE ENGINEERING RECOMMENDATION

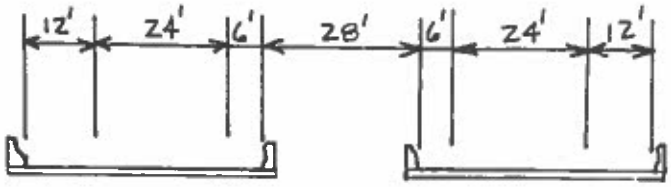
FORM: 20 DEC 1966

SKETCH OF ORIGINAL DESIGN

IDENTIFICATION NUMBER: B-4



RURAL TYPICAL SECTION
DEPRESSED MEDIAN



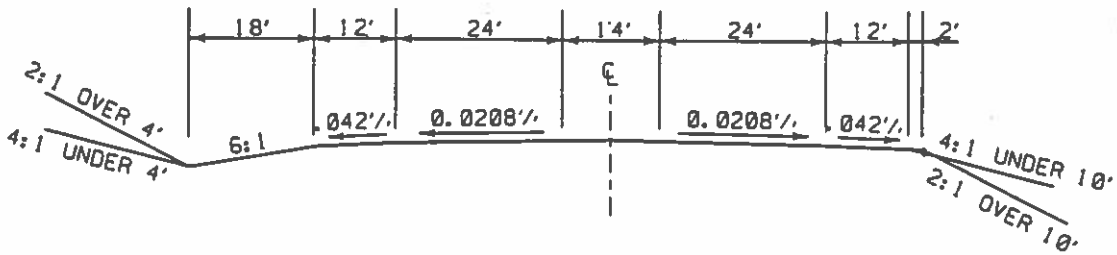
Bridge Typical Section

VALUE ENGINEERING RECOMMENDATION

FORM: 20 DEC 1966

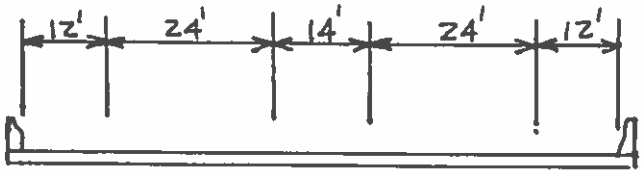
SKETCH OF RECOMMENDED DESIGN

IDENTIFICATION NUMBER: B-4



URBAN TYPICAL SECTION

5 - LANE SECTION



Bridge Typical Section

VALUE ENGINEERING RECOMMENDATION

FORM: 20 DEC 1996

CALCULATIONS

IDENTIFICATION NUMBER: B-4

Pavement Cost

Cost per m^2 of pavement

4- 3.6m lanes, 2-3.6m shoulders, 2-1.8 m inside shoulders

= 25.2 m^2/m of roadway

Length of project = 5.793 km = 5793 m

Total pavement area = 145,984 m^2

Total Cost of surfacing = $4,068,960 (from estimate)

Cost per m^2 of pavement = 4,068,960 / 145,984 = $27.87/$m^2$

Begining of 5-lane urban section = 14+200

End of 5-lane urban section = 16+812 (end of project)

length of 5 lane = 2612 m

Width of 5 lane urban section

4-3.6m lanes, 2-3.6m shoulder, 1-4.2m median

∴ = 25.8 m

Extra Pavement in 5 lane section = 25.8-25.2 = 0.6 m.

VALUE ENGINEERING RECOMMENDATION

FORM: 20 DEC 1996

CALCULATIONS

IDENTIFICATION NUMBER: B-4

Extra pavement area = 0.6 m x 2612 m = 1567.2 m^2

Extra pavement cost = 1567.2 m^2 x $27.87/$m^2$ = $43,677.86

Say = $42,678

VALUE ENGINEERING RECOMMENDATION

CALCULATIONS

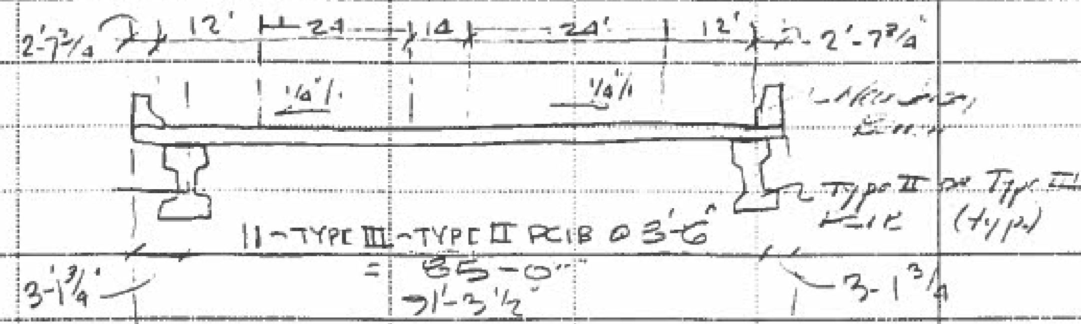
FORM: 20 DEC 1996

IDENTIFICATION NUMBER: B-4

CALCULATE QUANTITIES OF ONE STRUCTURE

OVER DRAINAGE CREEK & OVERFLOW STRUCTURE

TEMPLATE OF PROPOSED ONE STRUCTURE



DETERMINE SQUARE FOOT COST OF STRUCTURE

Superstructure

92' width 470' length (from Debbie - Detail 3)

10" slab New Jersey Barriers

COST OF SUPERSTRUCTURE

DECK - (92)(470)(0.83)/27 = 1334 yd³

NJB - 111.4 yd³

DIAPHRAGMS (INT, END BENT, PIERS) = 305 yd³

TOTAL CLASS "AA" = 1750.4 y.

1750.4 (0.7 ...) - 1332 ... x $3.3 ... = $13,2[illegible]

REINFORCEMENT 500,000# (0.56) $280,000

VALUE ENGINEERING RECOMMENDATION

FORM: 20 DEC 1996

CALCULATIONS

IDENTIFICATION NUMBER: B-4 Page 10 of

TOTAL SUPERSTRUCTURE

= 519,282 + 280,000 = 799,282

SUBSTRUCTURE

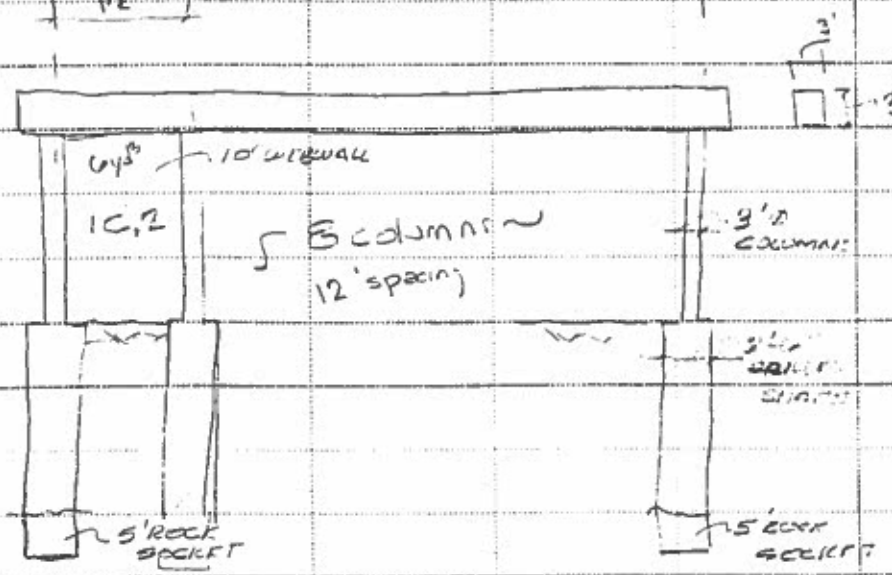
PIER #1 = #2 (ASSUME SAME HEIGHT)

USE DRILLED SHAFTS

COLUMN HEIGHT = 19.2'

DRILLED SHAFT (COL) = 31'

" " (ROCK) 5'



CAP (92)(3)(3)/27 = 31 yd³

COLUMN 34 yd³

CAISSON (COL) (9.7m) 31' =

CAISSON (ROCK) (1.5m) 5'

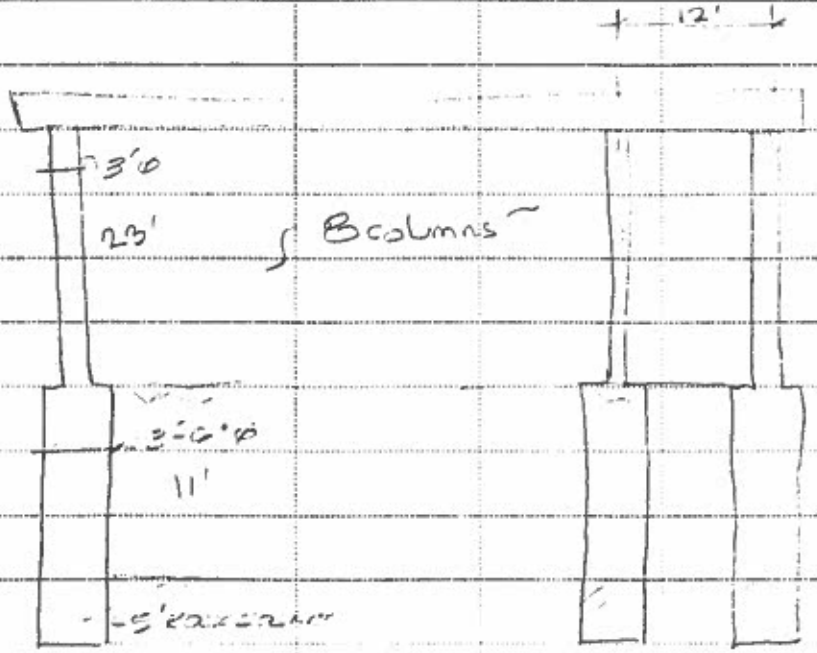
VALUE ENGINEERING RECOMMENDATION

FORM: 20 DEC 1996

CALCULATIONS

IDENTIFICATION NUMBER: B-4

	WEB WALLS =	6 yd³ per box x 7 x 2 =		84 yd³
	CLASS "A" =		=	145 yd³
	TOTAL PIER #1 &	PIER #2 =	$63,000	
	PIERS #3 #4 #5 etc.			



(23)(12)(0.833) =	3.5 yd³ / box x 7 =	60 yd³	
60 x .706 = 42 m³ x 385		$16,330	

VALUE ENGINEERING RECOMMENDATION

FORM: 20 DEC 1996

CALCULATIONS

IDENTIFICATION NUMBER: B-4

	COST FOR PIER			
	PIER #1	76,000	{ DRILLED SHAFT CAP, PIER CLEANING, WORKMAT, REINF. }	
	PIER #2	76,000		
	PIER #3	86,000		
	PIER #4	86,000		
	#5	86,000		
	#6	86,000		
		$ 496,000		
	I.F. #1 - #2	8500 + 8500	+ $17,000	
	PILES		29,000 $/m²	
	REINFORCEMENT		10 $/m²	
	BEAMS		442 $/m²	
	FINAL COST:			
		$ 1,792,232		
	COST PER SQUARE FOOT			
		= 1,792,232 / (470 × 12)		
		= $ 41.49 / ft²		

VALUE ENGINEERING RECOMMENDATION

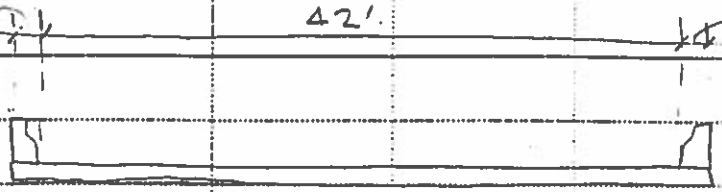
FORM: 20 DEC 1996

CALCULATIONS FOR ORIGINAL DESIGN

IDENTIFICATION NUMBER: B-4

COST ESTIMATE FOR TWIN STRUCTURES OVER DRAKES CREEK AND OVERFLOW

TEMPLATE



OVER DRAKES CREEK

COST - $41.41 / SQ FT.

LENGTH = 470'

WIDTH = 47.29

AREA = 22,229 SQ. FT.

COST PER BRIDGE (N.B) - 22,229 (41.41) = $ 921,090

(S.B) - 22,229 (41.49) = $ 921,090

OVERFLOW

(213) (47.29) (N.B) = 10,073 ft² (41.49) = $ 417,416

(213) (47.29) (S.B) = 10,073 ft² (41.49) = $ 417,416

TOTAL FOR TWIN STRUCTURES = $2,677,011

VALUE ENGINEERING RECOMMENDATION

FORM: 20 DEC 1996

CALCULATIONS

IDENTIFICATION NUMBER: B-4

FINAL COSTS

BRIDGE OVER DRAKES CREEK

(470)(92)($41.44) = $1,792,282

BRIDGE OVER OVERFLOW

(213)(92)($41.44) = $812,058

"As Is" Earthwork Quantities

Exc. = 296,274 m^3, Emb. = 297,162 m^3

Assume 15% shrinkage

Needed Emb. = 297,162 x 1.15 = 341,736 m^3

− 296,274

45,462 m^3

From Drakes Creek to End of Project

	As Is	Flush Median	Change
Exc.	159,900	140,500	−19,400
Emb.	115,200	105,400	− 9800

Exc = 296,274 − 19400 = 276,874

Emb = 297,162 − 9800 = 287,362

Needed Embankment = 287,362 x 1.15 = 330,466

276,874

53,592 m^3

VALUE ENGINEERING RECOMMENDATION

FORM: 30 DEC 1996

COST ESTIMATE - FIRST COST

IDENTIFICATION NUMBER: B-4

Cost Item	Units	Unit Cost		Original Design		Recommended Design	
		$/Unit	Source Code	Num of Units	Total $	Num of Units	Total $
Additional Pavement	m^2	27.87	1	—	0	1567.2	42,678
Bridge over							
Drakes Creek	m^2	460.44		4001	1,842,220	3892	1,792,030
Overflow Bridge	m^2	460.44		1813	834,780	1764	812,220
Emb.-In-Place	m^3	6.00	1	297,162	1,782,972	287,362	1,724,172
					4,459,972		4,371,100

SOURCE CODE: 1 Project Cost Estimate; 2 CES Data Base; 3 CACES Data Base; 4 Means Estimating Manual; 5 Richardson's; 6 Vendor Lit or Quote (list name / details); 7 Professional Experience (List job if applicable); 8 Other Sources (specify)

VALUE ENGINEERING RECOMMENDATION

FORM 20 DEC 1996:

PROJECT U.S. 231
LOCATION: Bowling Green to Scottsville Road
STUDY DATE: March 17-21, 1997

IDENTIFICATION NUMBER: B-4 Option A
FUNCTION OF COMPONENT BEING CHANGED: General Project
DESCRIPTIVE TITLE OF RECOMMENDATION: From Dye Ford Road to South of Drake's Creek Bridge, the roadway section will be an urban 5-lane section with shoulders. Option A includes median Barrier.

ORIGINAL DESIGN:

North of Dye Ford Road, the roadway section is a 5-lane urban section including: curb and gutter, sidewalk, and storm drainage collection. From Dye Ford Road to about 0.4 mile north of US 31E the roadway section is a 4-lane rural section with a depressed 40-foot median and a minimum 1200-foot spacing of access points. There will be two, 2-lane bridges in each direction, one crossing Drake's Creek and one crossing the Drake's Creek backwater area with a bridge width of 42.0 ft.

RECOMMENDED CHANGE:

It is recommended that a new 5-lane urban roadway section with shoulders will connect to the presently designed 5-lane urban roadway with curb and gutters at Dye Ford Road and extend to the south for approximately 2.6 kilometers (1.6 miles). The 5-lane urban section north of Dye Ford Road includes curb and gutter, sidewalk, and storm drain collect system. The recommended new 5-lane urban section continuing south from Dye Ford Road will include 12-foot wide outside shoulders in lieu of curb and gutter. The new section will extend from Dye ford Road to station 14 + 200 (approximately) 200 meters south of Duke's Bridge.

SUMMARY OF COST ANALYSIS			
	First Cost	O & M Costs (Present Worth)	Total LC Cost (Present Worth)
ORIGINAL DESIGN	4,459,972	0	4,459,972
RECOMMENDED DESIGN	5,075,110	0	5,075,110
ESTIMATED SAVINGS OR (COST)	(615,138)	0	(615,138)

The roadway section will include two 3.3 meter driving lanes and a 3.3 meter outside shoulders in each direction. The new roadway segment will have a 1200-foot minimum between access points. A paved median will be 4.2 meters (14 feet) wide. A median Jersey barrier will be placed in the center of the 4.2 meter median. The new roadway section will extend across the Drake's Creek flood plain requiring two 26-meter (84-foot) wide bridges, (one bridge over Drake's Creek and one over Drake's Creek backwater area) in lieu of the 4 bridges required in the original design. **Recommendation B-4A is the same as B-4 with the addition of a median barrier.**

ADVANTAGES:

- A savings will be realized with the reduction of the embankment fill where the roadway crosses the flood plain of Drake's Creek.
- A savings will be realized with one 5-lane wide bridge crossing Drakes Creek and one crossing the backwater area as apposed to having 4 bridges as required in the regional design.
- A reduction of the required right of way width of about 7.9 meters (26 feet) will result by decreasing the median width. There will be a significant reduction of the impact on the adjacent property owners.
- A reduction of the right of way width will reduce the impact to the archeological site located immediately to the north of Drakes Creek.
- A continuity of the 5-lane urban section extending from the beginning of the project near I-65 to Station 14 + 200 (approximately 200 meters south of Drakes Creek Bridge) is consistent with the expected urban growth in the existing urban development immediately south of I-65. As urban development expands to the south, partial controlled access roadway section can be changed to access by permit when it becomes required.
- A shortened construction schedule will be realized.
- The option to construct a median barrier within the 4.2 -meter median, the potential of head on collisions will be reduced.
- Headlight glare will be somewhat reduced with a median barrier when compared to the paved 14-foot median with no barrier.

DISADVANTAGES:

- The roadway section with a 4.2-meter (14 foot) paved median will be less esthetically pleasing that the wider depressed 12-meter (40-foot) median.
- By reducing the 12-meter (40-foot) wide depressed median to a 4.2 meter (14 foot) wide paved median on-coming traffic will be closer together, as such:
  - There will be an increase of vehicle operator anxiety and decrease in comfort.
  - Headlight glare will be increased.
- A 4.2 meter (14 foot) wide median will have a higher potential for head on collisions. A 40-foot depressed median will virtually eliminate the potential for head on collisions.
- It will be more difficult for pedestrians to cross the roadway with a median barrier along the centerline.
- Additional drainage collection along centerline will be required with added cost and construction time.

JUSTIFICATION:

- By reducing the median width of the 40-foot wide depressed median to the paved 14-foot wide paved median the advantages outweigh the disadvantages.
- The extension of the urban roadway section past Drake's Creek is compatible with the predicted urbanization growth extending to the south from the northern end of the project limits.

- The 5-lane urban roadway section would be an extension of the presently designed 5-lane urban section. The proposed section would not be an isolated section of roadway within 14-mile long, 4-lane, 40-foot wide depressed median roadway section of the project.

- The 5-lane urban roadway section facilitates the design of one bridge crossing the Drake's Creek and one bridge crossing the backwater area as apposed to two bridges required for each direction of traffic.

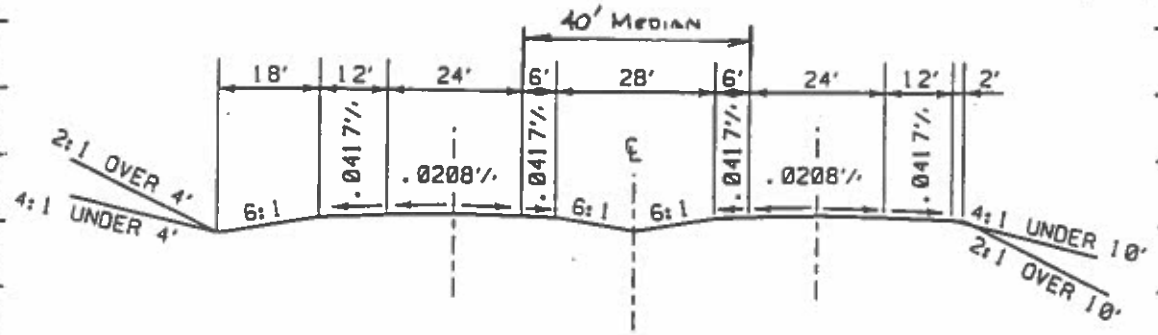
- Reducing the potential of head on collisions over a median without a barrier is significant.

VALUE ENGINEERING RECOMMENDATION

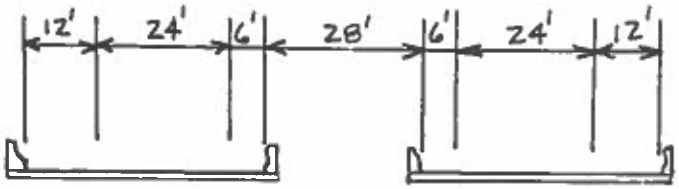
FORM: 20 DEC 1966

SKETCH OF ORIGINAL DESIGN

IDENTIFICATION NUMBER: B-4A



RURAL TYPICAL SECTION
DEPRESSED MEDIAN



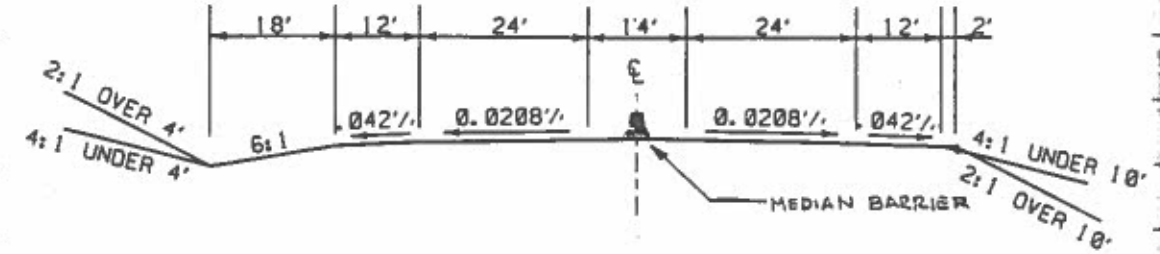
Bridge Typical Section

VALUE ENGINEERING RECOMMENDATION

FORM: 20 DEC 1966

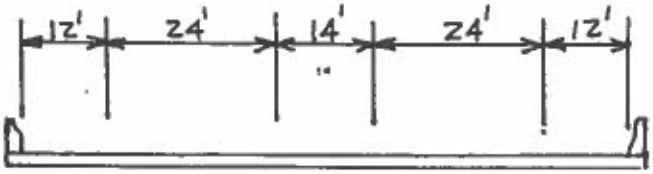
SKETCH OF RECOMMENDED DESIGN

IDENTIFICATION NUMBER: B-4 A



URBAN TYPICAL SECTION

5 - LANE SECTION



Bridge Typical Section

VALUE ENGINEERING RECOMMENDATION

CALCULATIONS

FORM: 20 DEC 1996

IDENTIFICATION NUMBER: B-4 A

Pavement Cost

Cost per m^2 of pavement

4- 3.6 m lanes, 2- 3.6 m shoulders, 2- 1.8 m inside shoulders

= 25.2 m^2 / m of roadway

Length of project = 5.793 km = 5793 m

Total pavement area = 145,984 m^2

Total Cost of surfacing = $4,068,960 (from estimate)

Cost per m^2 of pavement = 4,068,960 / 145,984 = $27.87/$m^2$

Begining of 5-lane urban section = 14+200

End of 5-lane urban section = 16+812 (end of project)

length of 5 lane = 2612 m

Width of 5 lane urban section

4- 3.6 m lanes, 2- 3.6 m shoulder, 1- 4.2 m median

= 25.8 m

Extra Pavement in 5 lane section = 25.8 - 25.2 = 0.6 m.

VALUE ENGINEERING RECOMMENDATION

FORM: 20 DEC 1996

CALCULATIONS

IDENTIFICATION NUMBER: B-4A

Extra pavement area = 0.6 m x 2612 m = 1567.2 m^2

Extra pavement cost = 1567.2 m^2 x $27.87/$m^2$ = $43,677.86

Say = $42,678

VALUE ENGINEERING RECOMMENDATION

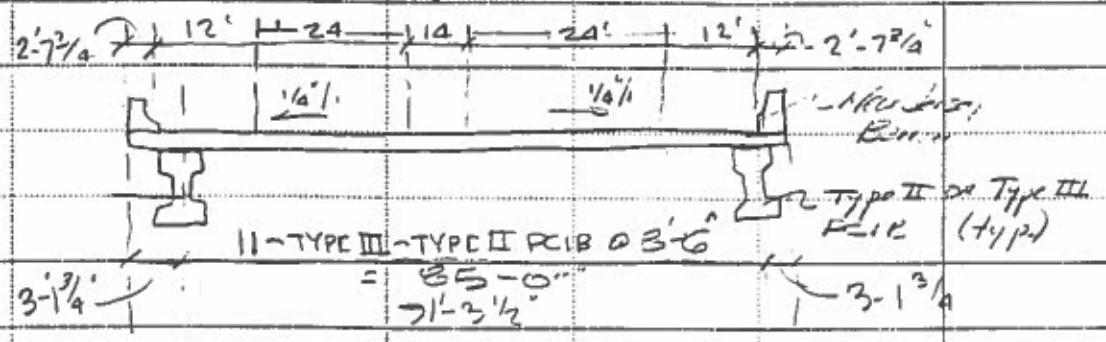
FORM: 20 DEC 1996

CALCULATIONS

IDENTIFICATION NUMBER: B-4A

CALCULATE QUANTITIES OF ONE STRUCTURE OVER DRAKES CREEK & OMIT 2ND STRUCTURE

TERMINATE OF PROPOSED ONE STRUCTURE



DETERMINE SQUARE FOOT COST OF STRUCTURE

Superstructure

92' width 470' length (from Debbie - Detail 3)

10" slab New Jersey Barriers

COST OF SUPERSTRUCTURE

DECK - (92)(470)(0.93)/27 = 1334 yd³

N.J.B. - 111.4 yd³

DIAPHRAMS (I.E.B, END BENT, PIERS) = 305 yd³

TOTAL CLASS "AA" = 1750.4 yd³

(1750 yd³)(0.7646) = 1338 m³ x 385 = $515,238 (a)

REINFORCEMENT - 500 lbs/ft³ (0.56) $230,000 (b)

VALUE ENGINEERING RECOMMENDATION

FORM: 20 DEC 1996

CALCULATIONS

IDENTIFICATION NUMBER: B-4A

TOTAL SUPERSTRUCTURE

= 519,282 + 280,000 = #799,282

SUBSTRUCTURE

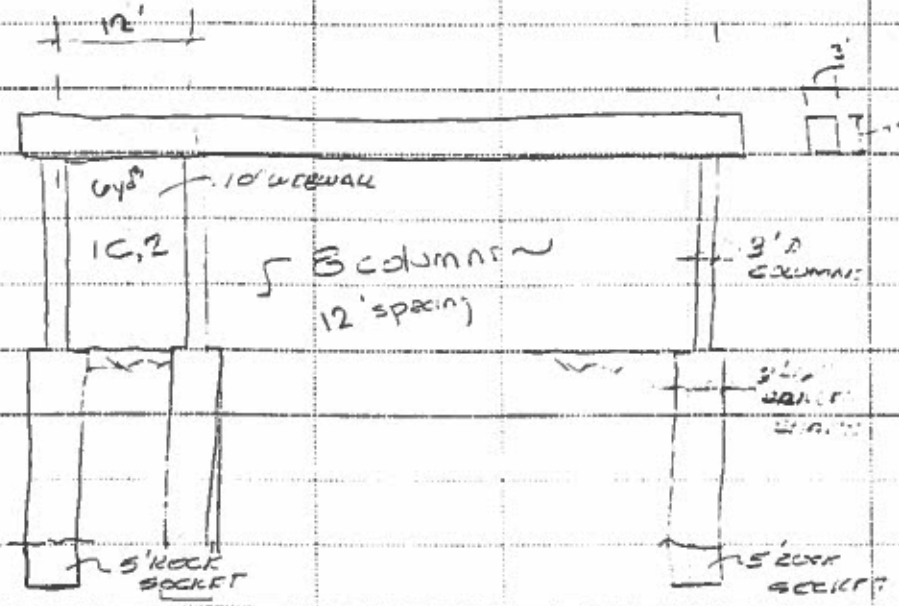
PIER #1 = #2 (ASSUME SAME HEIGHT)

USE DRILLED SHAFT:

COLUMN HEIGHT = 19.2'

DRILLED SHAFT (COH) = 31'

" " (ROCK) 5'



CAP (92)(3)(3)/27 = 31 yd³

COLUMN 3 yd³

CAISSON (COH) (9.7m) 31' =

CAISSON (ROCK) (1.5m) 5'

VALUE ENGINEERING RECOMMENDATION

FORM: 20 DEC 1996

CALCULATIONS

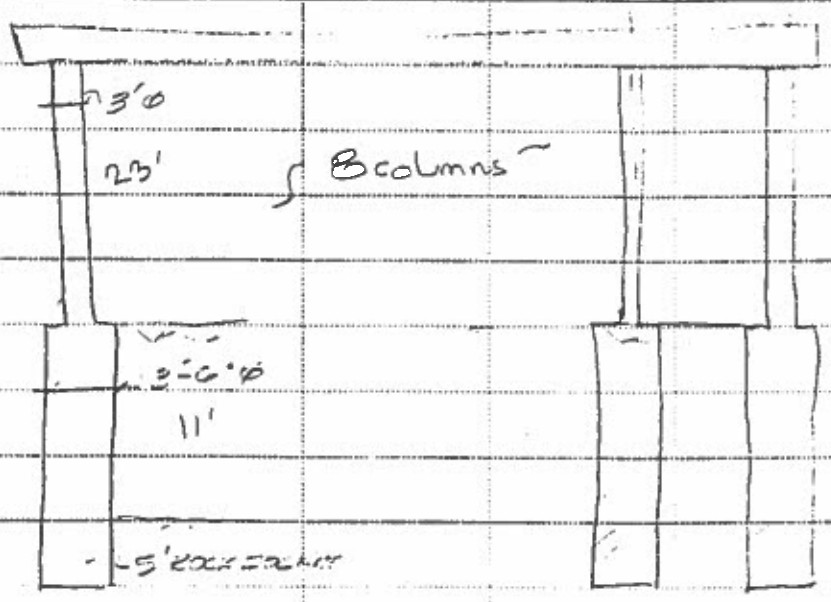
IDENTIFICATION NUMBER: B-4A

WEB WALLS – Cu d³ per bay ×7 ×2 = 84yd³

CLASS "A" = = 145yd³

TOTAL PILE #1 & PILE #2 = $63,000

PILE #3 #4 #5 #6



(23)(12)(0.833) = 8.5yd³/bay ×7 = 60yd³

60 × .706 = 42 m² × 385 $16,330

VALUE ENGINEERING RECOMMENDATION

FORM: 20 DEC 1996

CALCULATIONS

IDENTIFICATION NUMBER: B-4 A

	COSTS FOR PIERS		
	PIER #1	76,000	DRILLED SHAFT CAP PIER CLEANING WORK ALL REINF.
	PIER #2	76,000	
	PIER #3	86,000	
	PIER #4	86,000	
	#5	86,000	
	#6	86,000	
		$ 496,000	
	I.E.B #1 + #2	8500 + 8500 = $17,000	
	PILES		28,000 ≈
	REINFORCEMENT		10,000 ≈
	BEAMS		442,000 ≈
	FINAL COSTS		
		$ 1,792,232 ≈	
	COST PER SQUARE FOOT		
		= 1,792,232 / (470 × 92)	
		= $41.44 / ft²	

VALUE ENGINEERING RECOMMENDATION

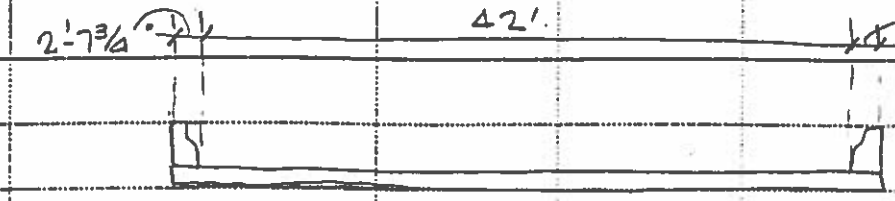
FORM: 20 DEC 1996

CALCULATIONS FOR ORIGINAL DESIGN

IDENTIFICATION NUMBER: B-4 A

COST ESTIMATE FOR TWIN STRUCTURES OVER DRAKES CREEK AND OVERFLOW

TEMPLATE



OVER DRAKES CREEK

COST = $41.44 / SQ FT.

LENGTH = 470'

WIDTH = 47.29

AREA = 22,228 SQ. FT.

COST PER BRIDGE (N.B) - 22,228 (41.44) = $ 921,090

(S.B) - 22,228 (41.44) = $ 921,090

OVER OVERFLOW

(213)(47.29) (N.B) = 10,073 ft² (41.44) = $ 417,416

(213)(47.29) S.B) = 10,073 ft² (41.44) = $ 417,416

TOTAL FOR TWIN STRUCTURES = $2,677,011

VALUE ENGINEERING RECOMMENDATION

FORM: 20 DEC 1996

CALCULATIONS

IDENTIFICATION NUMBER: B-4A

FINAL COSTS

BRIDGE OVER DRAKES CREEK

(470)(92)($41.44) = $1,792,282

BRIDGE OVER OVERFLOW

(213)(92)($41.44) = $812,058

VALUE ENGINEERING RECOMMENDATION

FORM: 20 DEC 1996

CALCULATIONS

IDENTIFICATION NUMBER: B-4 A

"As Is" Earthwork Quantities

Exc. = 296,274 m^3, Emb. = 297,162 m^3

Assume 15% shrinkage

Needed Emb. = 297,162 x 1.15 ≈ 341,736 m^3

− 296,274

45,462 m^3

From Drakes Creek to End of Project

	As Is	Flush Median	Change
Exc.	159,900	140,500	−19,400
Emb.	115,200	105,400	− 9800

Exc = 296,274 − 19400 = 276,874

Emb = 297,162 − 9800 = 287,362

Needed Embankment = 287,362 x 1.15 = 330,466

276,874

53,592 m^3

Median Barrier

Length of 5 lane section = 2612 m

Length of superelevated sections = 673 m + 266 m = 939 m

assume a median box inlet every 100 m

Need 10 median boxes

Approx. length of pipe needed to outlet boxes = 30 m

10 boxes x 30 m/box = 300 m

Assume 375 mm culvert pipe.

Need 10 metal end sections for pipes

Length of median barriers needed = 2612 m

Assume breaks in barriers for access control every 360 m

$2612/360 \approx 8$ breaks

Need 16 crash cushions

Less barrier wall for breaks - Assume 150 m/break

$8 \times 150 = 1200$ m

Total Barrier Wall = 2612 - 1200 m = 1412 m

VALUE ENGINEERING RECOMMENDATION

FORM: 30 DEC 1996

COST ESTIMATE - FIRST COST

IDENTIFICATION NUMBER: B-4A

Cost Item	Units	Unit Cost		Original Design		Recommended Design	
		$/Unit	Source Code	Num of Units	Total $	Num of Units	Total $
Additional Pavement	m^2	27.87	1	—	0	1567.2	42,678
Bridge over							
Drakes Creek	m^2	460.44	7	4001	1,842,220	3892	1,792,030
Overflow Bridge	m^2	460.44	7	1813	834,780	1764	812,220
Emb.-In-Place	m^3	6.00	1	297,162	1,782,972	287,362	1,724,172
BARRIER WALL FROM PAGE 2							704,010
					4,459,972		5,075,110

SOURCE CODE:
1 Project Cost Estimate
2 CES Data Base
3 CACES Data Base
4 Means Estimating Manual
5 Richardson's
6 Vendor Lit or Quote (list name / details)
7 Professional Experience (List job if applicable)
8 Other Sources (specify)

VALUE ENGINEERING RECOMMENDATION

FORM: 30 DEC 1996

COST ESTIMATE - FIRST COST

IDENTIFICATION NUMBER: B-4A

Cost Item	Units	Unit Cost		Original Design		Recommended Design	
		$/Unit	Source Code	Num of Units	Total $	Num of Units	Total $
Conc Median Barrier	m	$179	1	—		1412	252,748
Median Barrier Inlets	Each	$9800	1	—		10	98,000
375m Culvert Pipe	m	$92.54	1	—		300	27,762
Metal End Sections	Each	$550	1	—		10	5500
Crash Cushion	Each	$20,000	1	—		16	320,000
							704,010

SOURCE CODE:
1 Project Cost Estimate
2 CES Data Base
3 CACES Data Base
4 Means Estimating Manual
5 Richardson's
6 Vendor Lit or Quote (list name / details)
7 Professional Experience (List job if applicable)
8 Other Sources (specify)

VALUE ENGINEERING RECOMMENDATION

FORM 20 DEC 1996:

PROJECT U.S. 231
LOCATION: Bowling Green to Scottsville Road
STUDY DATE: March 17-21, 1997

IDENTIFICATION NUMBER: D-1
FUNCTION OF COMPONENT BEING CHANGED:
DESCRIPTIVE TITLE OF RECOMMENDATION: Eliminate Culvert Head walls.

ORIGINAL DESIGN:

All cross drains have inlet and outlet head walls.

RECOMMENDED CHANGE:

Design cross drains for rural roads as "End Projecting" outside clear zones for pipe 1200 mm and less.

SUMMARY OF COST ANALYSIS			
	First Cost	O & M Costs (Present Worth)	Total LC Cost (Present Worth)
ORIGINAL DESIGN	20,891	0	20,891
RECOMMENDED DESIGN	13,770	0	13,770
ESTIMATED SAVINGS OR (COST)	7,121	0	7,121

VALUE ENGINEERING RECOMMENDATION

IDENTIFICATION NUMBER: D-1 Page 2 of

ADVANTAGES:

- Ease of construction.
- Reduces cost.
- Inlet and outlet moved out of fill.
- Hard to backfill around head wall.
- Head wall tends to settle, causing a crack at end of pipe.

DISADVANTAGES:

- Could be damaged by mowers.
- Damage by vehicles out of control.
- Metal pipes need reducer at inlet.
- Concrete pipes may need positive joints where joint is outside of fill and in an unstable area.

JUSTIFICATION:

- Other states are currently using this detail with apparent success.
- Damage by out-of-control vehicles should be rare because this detail will only be used outside the clear zone. Inside the clear zone the detail will continue to be a head wall.

- Damage by mowers will be slight, if any, because the pipes will, as a hole, be located in areas where mowing is not done.

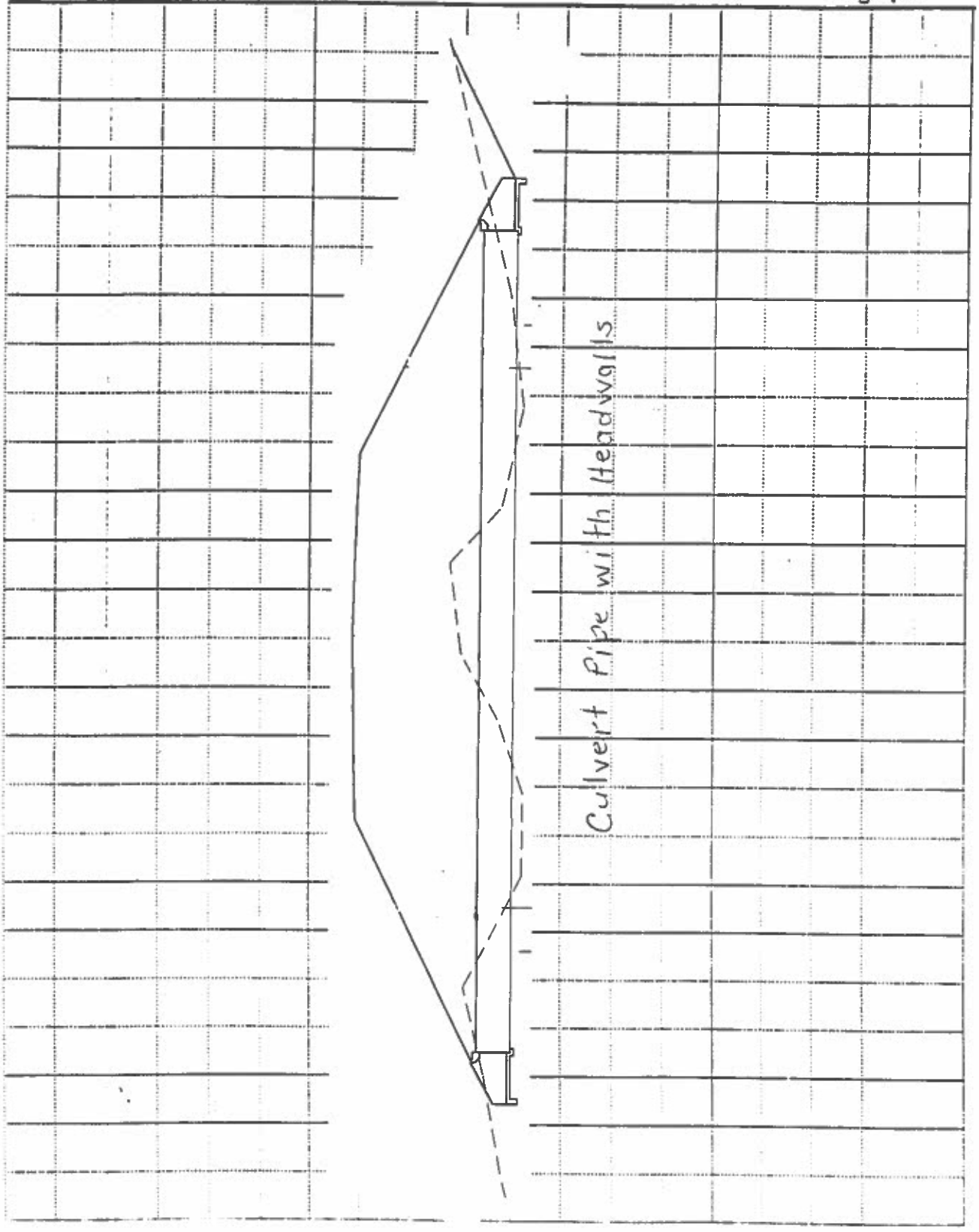
- This job is a good one to try this detail on because US-231 I a ridge road design having few cross drains compared to other roads. This would mean that this recommendation could be tried on this project with less risk. If it does not work - it can be reversed later by installation of head walls.

VALUE ENGINEERING RECOMMENDATION

FORM: 20 DEC 1966

SKETCH OF ORIGINAL DESIGN

IDENTIFICATION NUMBER: D-1

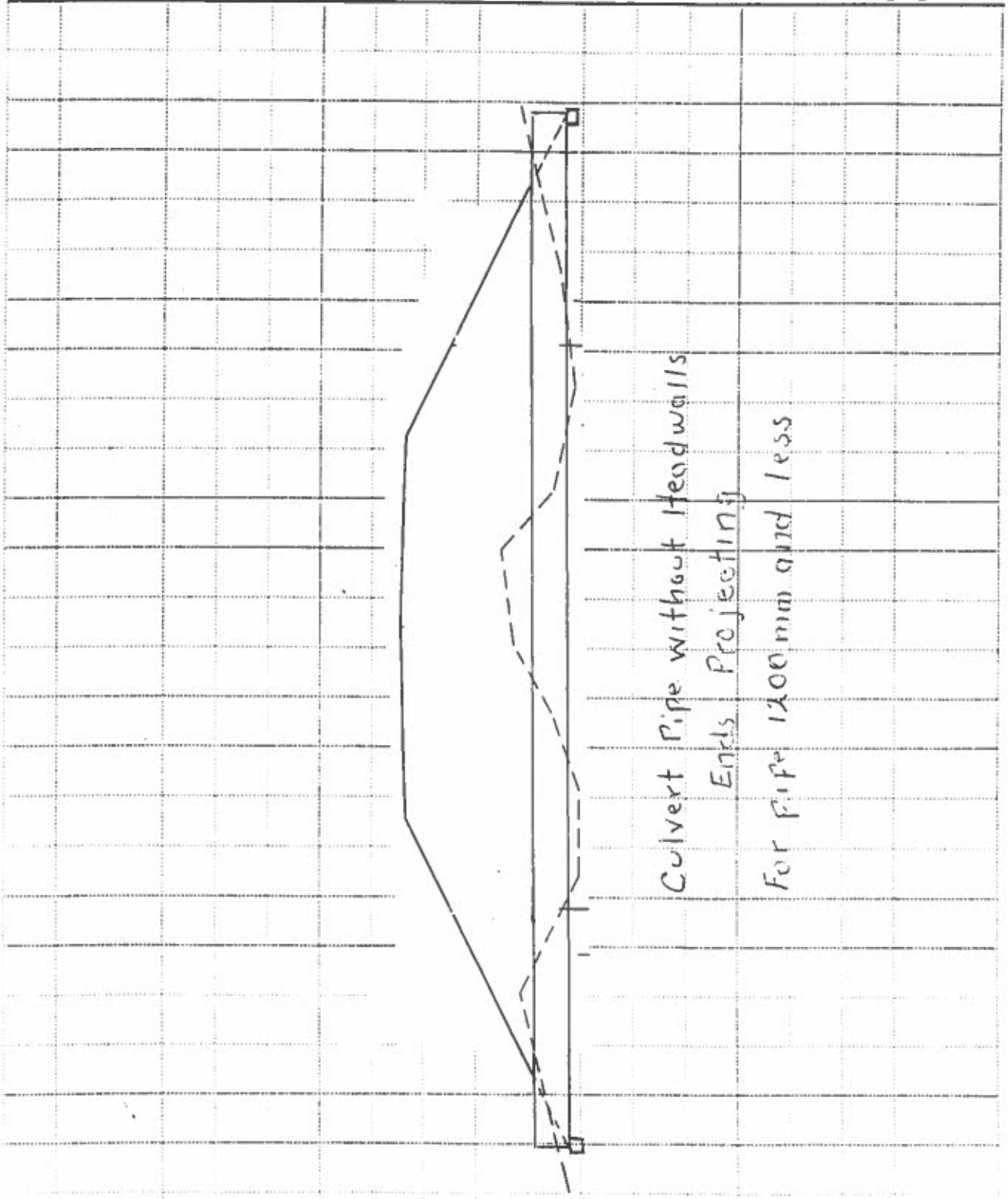


VALUE ENGINEERING RECOMMENDATION

FORM: 20 DEC 1966

SKETCH OF RECOMMENDED DESIGN

IDENTIFICATION NUMBER: D-1



VALUE ENGINEERING RECOMMENDATION

FORM: 20 DEC 1996

CALCULATIONS

IDENTIFICATION NUMBER: D-1

Original Design - Items to be deducted

Headwalls		Conc. CM		Steel kg
450mm Pipe	38x.71 =	27.00	38x3.6 =	137
600	2x.99 =	2.00	2x4.1	8
750	1x2.57 =	2.57	1x127 =	127
900	3x 3.29	9.87	3x165	495
1050	3x4.09	12.27	3x195	585
	Total	53.71		1352

Proposed Revision - Items to be added

	M	Anchor Conc.	Riprap MT
450mm pipe	34	4.56	76
600	3	.60	6
750	3	.36	6
900	8	.80	16
1050	12	1.80	36
		8.12	140

VALUE ENGINEERING RECOMMENDATION

FORM. 30 DEC 1996

COST ESTIMATE - FIRST COST

IDENTIFICATION NUMBER: D-1

Cost Item	Units	Unit Cost		Original Design		Recommended Design	
		$/Unit	Source Code	Num of Units	Total $	Num of Units	Total $
Original Design - Items to be deducted							
Headwall Conc.	C.M	$360	8100	53.71	19,336		-0-
Steel	Kg	1.15	8150	1352	1,555		-0-
			Total		20,891		-0-
Recommended - Items to be added							
450mm Pipe	M	$102	462		-0-	34	3,468
600mm Pipe	M	130	464		-0-	3	390
750mm Pipe	M	143	466		-0-	3	429
900mm Pipe	M	185	468		-0-	8	1,480
1050mm Pipe	M	225	469		-0-	12	2,700
Anchor Conc.	C.M	360	8100		-0-	8.12	2,923
Riprap	MT	17	2484		-0-	140	2,380
					Total		13,770

SOURCE CODE:
1 Project Cost Estimate
2 CES Data Base
3 CACES Data Base
4 Means Estimating Manual
5 Richardson's
6 Vendor Lit or Quote (list name / details)
7 Professional Experience (List job if applicable)
8 Other Sources (specify)

VALUE ENGINEERING RECOMMENDATION

FORM 20 DEC 1996

PROJECT U.S. 231
LOCATION: Bowling Green to Scottsville Road
STUDY DATE: March 17-21, 1997

IDENTIFICATION NUMBER: P-1
FUNCTION OF COMPONENT BEING CHANGED:
DESCRIPTIVE TITLE OF RECOMMENDATION: Add perforated pipe in curb and gutter section for drainage purposes.

ORIGINAL DESIGN:

Curb and gutter with bituminous pavement underlain by Dense Graded Aggregate Base. There is no provision for subbase drainage.

RECOMMENDED CHANGE:

Curb and gutter with bituminous pavement underlain by a crushed stone base. Perforated pipe added at gutter lines to drain pavement.

SUMMARY OF COST ANALYSIS			
	First Cost	O & M Costs (Present Worth)	Total LC Cost (Present Worth)
ORIGINAL DESIGN	480,761	451,650	932,411
RECOMMENDED DESIGN	596,917	203,760	800,677
ESTIMATED SAVINGS OR (COST)	(116.156)	247,890	131,734

ADVANTAGES:

- Longer pavement life
- Less pavement rutting

DISADVANTAGES:

- Additional cost.

JUSTIFICATION:

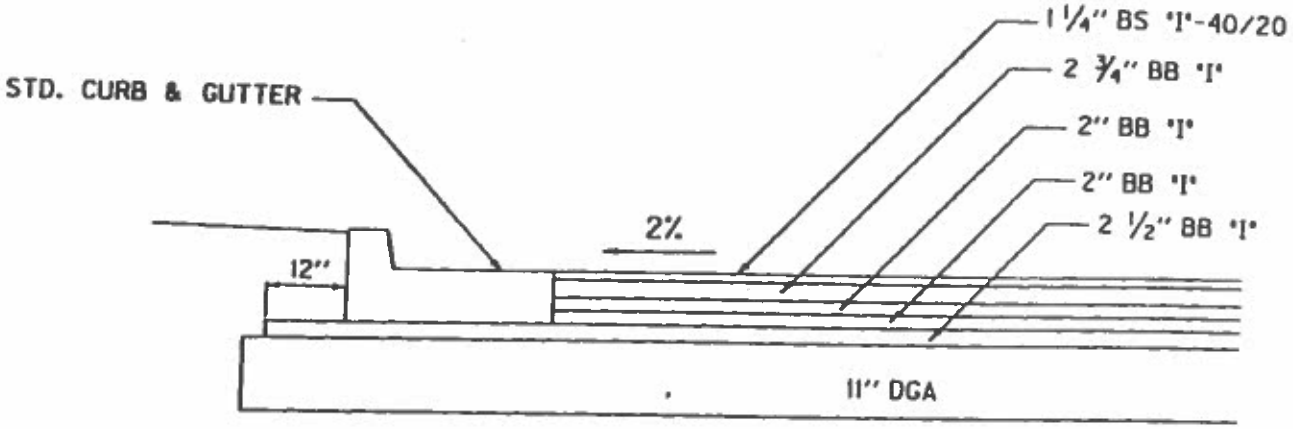
- Providing positive drainage for the subbase will increase the life of the pavement and decrease the amount of rutting. Rutting is occurring in the existing urban section that
- connects to this project. By reducing the rutting, maintenance costs will be reduced and there will be less disruption to the traveling public.

VALUE ENGINEERING RECOMMENDATION

FORM: 20 DEC 1966

SKETCH OF ORIGINAL DESIGN

IDENTIFICATION NUMBER: P-1



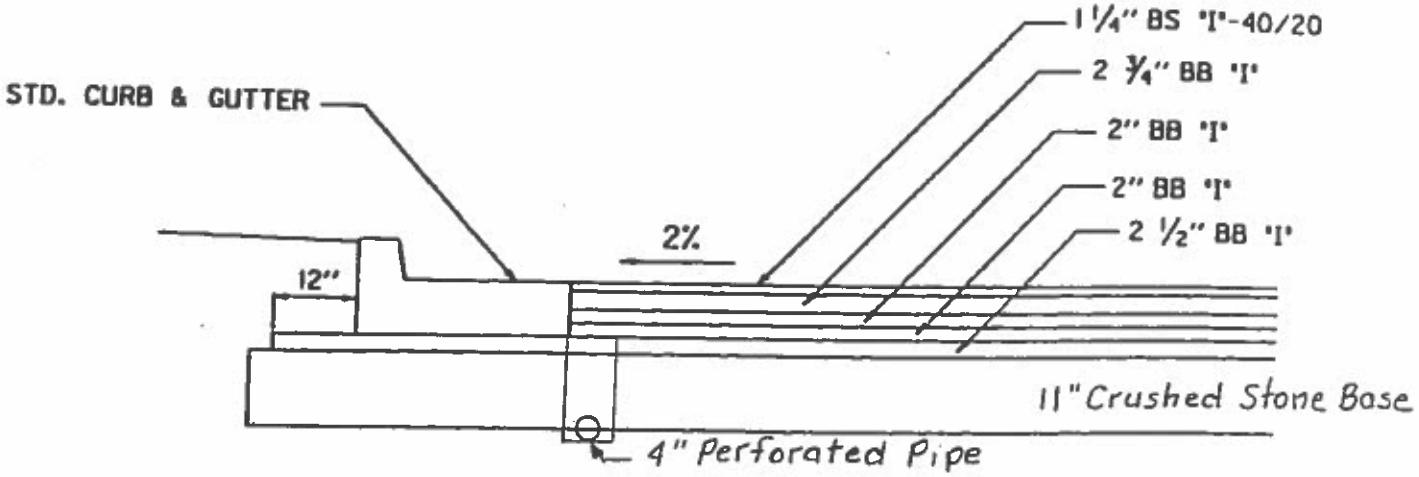
Original Pavement Design

VALUE ENGINEERING RECOMMENDATION

FORM: 20 DEC 1966

SKETCH OF RECOMMENDED DESIGN

IDENTIFICATION NUMBER: P-1



Reccmmended section with Crushed Stone Base and 4" Perforated Pipe

VALUE ENGINEERING RECOMMENDATION

COST ESTIMATE - FIRST COST

FORM. 30 DEC 1996

IDENTIFICATION NUMBER: P - 1

Cost Item	Units	Unit Cost		Original Design		Recommended Design	
		$/Unit	Source Code	Num of Units	Total $	Num of Units	Total $
DEA Base	M-Ton	15.60		30,818	480,761		
Crushed Stone Fill	M-Ton	17.48				30,515	533,699
4" Perforated Pipe	M	13.63				3414	46,533
4" Non-Perf. Pipe	M	22.57				48	1,083
Size No. 57 Stone	M-Ton	16.50				543	8,960
Hdwl Cone.	C.M.	360				4.56	1,642
					Total		590,917

SOURCE CODE:
1 Project Cost Estimate
2 CES Data Base
3 CACES Data Base
4 Means Estimating Manual
5 Richardson's
6 Vendor Lit or Quote (list name / details)
7 Professional Experience (List job if applicable)
8 Other Sources (specify)

Maintence required for approximately 1,707m times 1463m of asphalt paving. The total area or 24,973 m^2 will require 8,241 m^2 to be "wedged' and 16,732 m^2 to be milled. Final work will be an overlay of 1.5" over 24,973 m^2. **Note: m^2, *means* meters squared**

2677 Bit Pave Milling & Texturing

16,732 m^2 x 0.038m = 636m^3

3,800 (Lbs/cy) / 0.764 = 4,947 (Lbs/m^3)

4,974 Lbs/2000 = 2.49 (Tons/m^3)

2.49 x 0.9078 = 2.26 MT/m^3

636 x 2.26 = 1,437 MT

1,437MT x 21.94 ($/MT) = $31,528

2700 Wedging

8,241m^2 x 0.038m = 313m^3

5,366 Lbs / 2000 = 2.68 Tons / m^3

2.68 x 0.9078 = 2.43 MT/m^3

313 m^3 x 2.43 (MT/m^3) = 751 MT

751 x 33.10 = $24,858

9149 Bit Conc Surf (Mod)

24,973 x 0.038 = 949 m^3

4,100 (Lbs/cy) / 0.764 =5.366 Lbs/m^3

5366 Lbs/2,000 = 2.68 Tons/m^3

2.68 x 0.9078 = 2.43 MT/m^3

949m^3 x 2.43MT/m^3 = 2,306MT

2.306MT x $43.08 /MT = $99,342

Subtotal = $ 155,728

Mobilization 3% = $ 4,672

Demobilization 1.5% = $ 2406

Engr./Owner Cont. 10% = 16,281

Total = $179,087

Use $180,000

VALUE ENGINEERING RECOMMENDATION

FORM 30 DEC. 1996 **COST ESTIMATE - O & M (LIFE CYCLE) COST**

IDENTIFICATION NUMBER: P-1

PRESENT WORTH METHOD
LIFE CYCLE PERIOD (YEARS) = 20
ANNUAL PERCENTAGE RATE = 4%

Dollars in table are $ times 1,000

Initial Costs				Original Design PW $		Reccomd Design PW $
DGA Base				480.76		
Crushed Stone						596.92
& PIPE						
Sub Totals of Initial Costs PW $						

Later Costs Single Expenditure	In The Yr	PW Factor	Original Design		Recommended Design	
			Est $	PW $	Est $	PW $
MAINTENANCE	5	.8219	180	147.94		
"	10	.6756	180	121.61	180	121.61
"	15	.5553	180	99.95		
"	20	.4564	180	82.15	180	82.15
Sub Total of Single Expenditure Costs PW $				451.65		203.76

Later Costs Annual Expense	For How Many Yrs	PW Factor	Original Design		Recommended Design	
			Est $	PW $	Est $	PW $
Sub Totals of Annual Expense Costs PW $						
Totals PW $ for Original & Recommended				932.41		800.68
Total PW $ Savings (or Added Cost) for Recommended Design						131.73

VALUE ENGINEERING RECOMMENDATION

FORM 20 DEC 1996:

PROJECT U.S. 231
LOCATION: Bowling Green to Scottsville Road
STUDY DATE: March 17-21, 1997

IDENTIFICATION NUMBER: S-1
FUNCTION OF COMPONENT BEING CHANGED:
DESCRIPTIVE TITLE OF RECOMMENDATION: Modular Block Retaining Wall at Greenwood High School.

ORIGINAL DESIGN:

The original design included a Standard, non-reinforced, gravity type retaining wall between Sta. 1+499. This wall is used to prevent encroachment on the parking lot of Greenwood High School.

RECOMMENDED CHANGE:

Use a modular block retaining wall instead of a standard gravity wall.

SUMMARY OF COST ANALYSIS			
	First Cost	O & M Costs (Present Worth)	Total LC Cost (Present Worth)
ORIGINAL DESIGN	19,388	0	19,388
RECOMMENDED DESIGN	10,296	0	10,296
ESTIMATED SAVINGS OR (COST)	9,092	0	9,092

VALUE ENGINEERING RECOMMENDATION

IDENTIFICATION NUMBER: S-1 Page 2 of

ADVANTAGES:

- Easier to Construct.
- Doesn't require form work.
- Doesn't require curing time.
- More esthetically pleasing.
- Easier to construct curves in wall alignment.
- Less prone to vandalism and graffiti.
- Doesn't require skilled labor to build.
- Construction time can be reduced.

DISADVANTAGES:

- Has not been used frequently by the Department.

JUSTIFICATION:

- The subject wall will be in the direct view of Greenwood high School and parking lot.
- Wall construction activities will disrupt use of the parking lot.
- The standard gravity walls are not attractive and are susceptible to movements and differential settlements.

- Modular block walls are more attractive and can be provided in a variety of colors and styles.

- Modular block walls are flexible and can withstand movements and settlements.

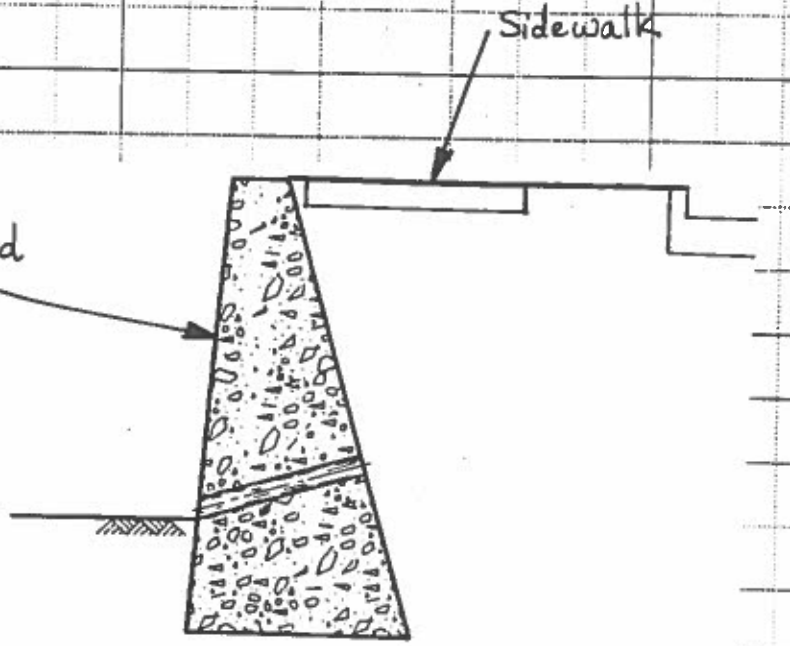
- Modular block walls are easier and quicker to construct. The impact on the parking lot would be less than that of the form work and curing times associated with the standard gravity wall.

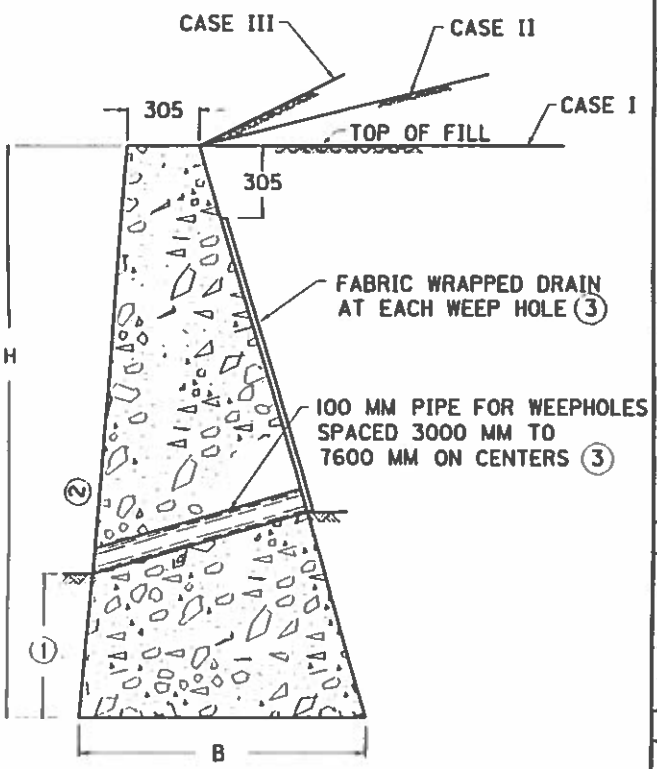
VALUE ENGINEERING RECOMMENDATION

FORM: 20 DEC 1966

SKETCH OF ORIGINAL DESIGN

IDENTIFICATION NUMBER: S-1





CASE I, CASE II, AND CASE III

H	B	END AREA SQ. METER	VOLUME CU. M./M
CASE I OR II OR III			
915	460	0.348	0.348
1065	535	0.447	0.447
1220	610	0.557	0.557
1370	685	0.679	0.679
1525	765	0.813	0.813
1675	840	0.958	0.958
1830	915	1.115	1.115
1980	990	1.283	1.283
2135	1065	1.463	1.463
2285	1145	1.655	1.655
2440	1220	1.858	1.858
2590	1295	2.073	2.073
2745	1370	2.299	2.299
2895	1450	2.537	2.537
CASE I			
3050	1525	2.787	2.787
3200	1600	3.048	3.048
3350	1675	3.32	3.321
3505	1755	3.606	3.606
3655	1830	3.902	3.902
CASE II OR III			
3050	1830	3.252	3.252
3200	1905	3.536	3.536
3350	1980	3.832	3.832
3505	2055	4.14	4.140
3660	2135	4.459	4.459

NOTES

THE RETAINING WALL DEPICTED ON THIS DRAWING SHALL BE USED WHEN THE HEIGHT (H DIMENSION) OF THE WALL IS 3660 MM OR LESS PROVIDED THE FILL COMPLIES WITH THE FOLLOWING CONDITIONS:

CASE I - WALL BACKFILL SLOPES DOWN , IS LEVEL, OR SLOPES UP FROM WALL AT 1:20 OR FLATTER. THIS LOW SLOPE ALLOWS FOR BACKFILLS WHICH WOULD BE LEVEL EXCEPT FOR THE SLOPE REQUIRED TO FACILITATE PROPER DRAINAGE.

CASE II - BACKFILL SLOPES UP STEEPER THAN 1:20 BUT NOT STEEPER THAN 1:4.

CASE III - BACKFILL SLOPES UP STEEPER THAN 1:4 BUT NOT STEEPER THAN 1:2. WHEN H DIMENSION IS GREATER THAN 2440 MM (HEIGHT OF EXPOSED FACE GREATER THAN 1830 MM INCREASE THE EMBEDMENT DEPTH TO 1/4H, (1).

SPECIAL DESIGNS SHALL BE REQUIRED WHEN THE FOLLOWING CONDITIONS EXIST:

(A) WALL HEIGHT IS GREATER THAN 3660 MM

(B) WALL IS SURCHARGED WITH DEAD LOAD FILL SLOPES STEEPER THAN 1:2 .

(C) WALL IS SURCHARGED WITH A LIVE LOAD WITHIN THE LIMITS OF A 1:1 SLOPE EXTENDING FROM THE BASE OF THE WALL.

AREAS AND VOLUMES HAVE BEEN COMPUTED WITHOUT DEDUCTING FOR BEVELED EDGES OR PIPE DRAINS. WHEN A RETAINING WALL VARIES IN HEIGHT, THE PRISMOIDAL FORMULA SHALL BE USED IN COMPUTING VOLUMES.

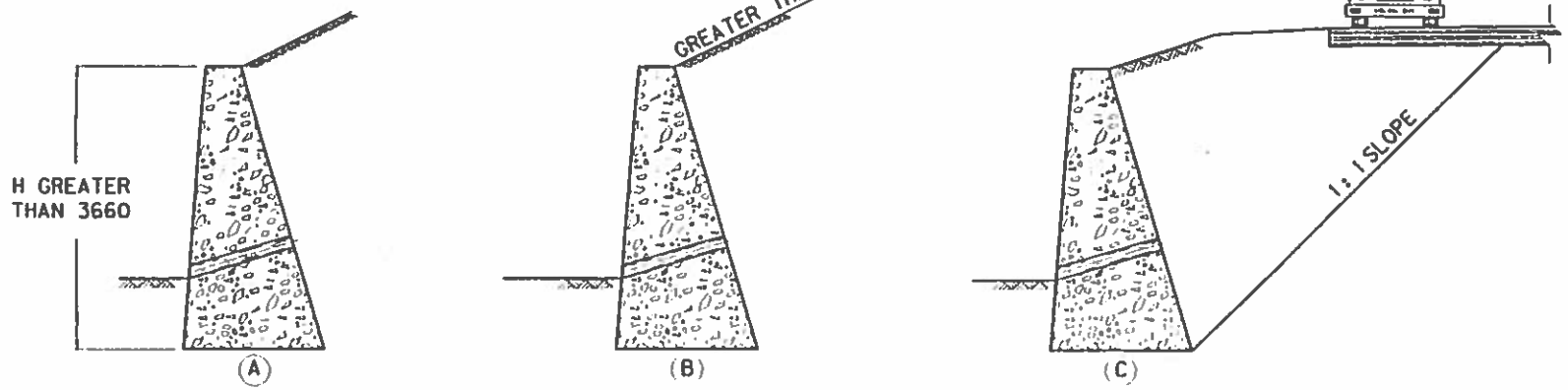
(1) MINIMUM EMBEDMENT VALUE FOR FIRM EARTH IS 610 MM; CASE III REQUIRES AN EMBEDMENT OF 1/4H FOR A WALL OVER 2440 MM (SEE CASE III ABOVE).

(2) BATTER: CASE I, AND CASE II
H = 915 MM TO LESS THAN 1525 MM (VERTICAL)
H = 1525 MM TO LESS THAN 3050 MM (1:12)
H = 3050 MM TO 3660 MM (1:6)

CASE III
H =915 MM TO LESS THAN 1525 MM (12:1)
H =1525 MM TO 3660 MM (6:1)

(3) FABRIC WRAPPED DRAINS AND 100 MM PIPE FOR WEEPHOLES SHALL BE INCLUDED IN THE UNIT PRICE BID FOR GRAVITY TYPE RETAINING WALLS.

4. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS SHOWN OTHERWISE.



SPECIAL DESIGNS REQUIRED

KENTUCKY DEPARTMENT OF HIGHWAYS

RETAINING WALL
GRAVITY TYPE
NON - REINFORCED

STANDARD DRAWING NO. RGX-002-06

SUBMITTED John B Scalf 10 3 94

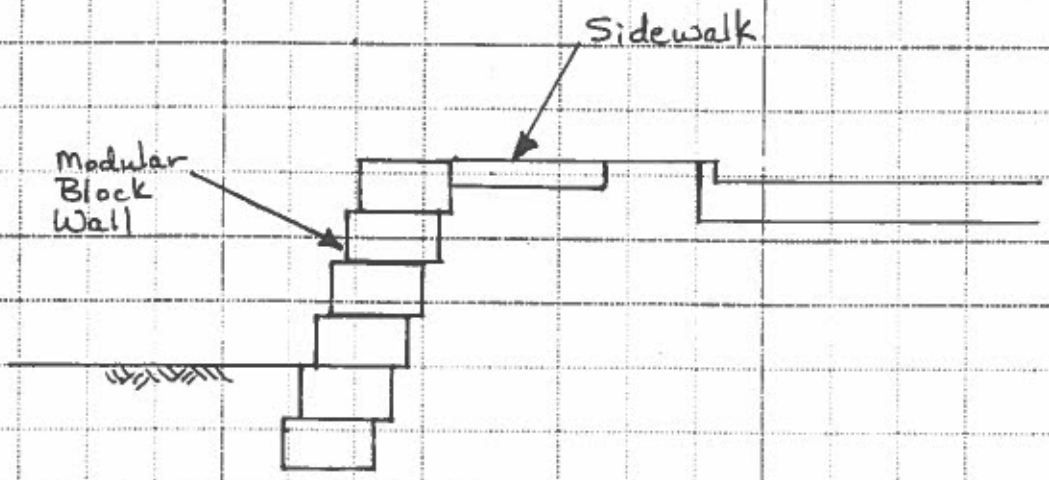
APPROVED [signature] 10 3 94

VALUE ENGINEERING RECOMMENDATION

FORM: 20 DEC 1966

SKETCH OF RECOMMENDED DESIGN

IDENTIFICATION NUMBER: S-1



VALUE ENGINEERING RECOMMENDATION

FORM: 20 DEC 1996

CALCULATIONS

IDENTIFICATION NUMBER: S-1

Begin Wall @ 1+380

End Wall @ 1+499

Sta.	Wall Height (m)	Concrete Volume m^3/m of wall	Concrete Volume (m^3)
1+380	0.9	0.348	7.95
1+400	1.0	0.447	9.49
1+420	1.1	0.502	10.59
1+440	1.2	0.557	10.59
1+460	1.2	0.557	10.59
1+480	1.2	0.557	9.54
1+499	1.0	0.447	

Total Conc. Vol. = 58.75 m^3

Sta.	Wall Height (m)	Sq. m of Wall face
1+380	0.9	19
1+400	1.0	21
1+420	1.1	23
1+440	1.2	24
1+460	1.2	24
1+480	1.2	20.9
1+499	1.0	

Total Wall Face = 132 m^2

VALUE ENGINEERING RECOMMENDATION

FORM 30 DEC 1996

COST ESTIMATE - FIRST COST

IDENTIFICATION NUMBER: S-1

Cost Item	Units	Unit Cost		Original Design		Recommended Design	
		$/Unit	Source Code	Num of Units	Total $	Num of Units	Total $
Concrete, Class A (unreinforced Conc)	m^3	$330	1	58.75	$19,388		
Retaining Wall	m^2	$78	7	—		132	$10,296
NO APPARENT LCC EFFECT.							

SOURCE CODE:
1 Project Cost Estimate
2 CES Data Base
3 CACES Data Base
4 Means Estimating Manual
5 Richardson's
6 Vendor Lit or Quote (list name / details)
7 Professional Experience (List job if applicable)
8 Other Sources (specify)

SECTION 4 - DESIGN SUGGESTIONS

Several Design Suggestions are presented in this section. Design Suggestions are ideas that were, in the opinion of the team, good ideas, but were, never-the-less, not selected for development and writeup as a formal recommendation. Design Suggestions, by definition, have not been developed (proven) through team development and writeups. The team presents these ideas for further consideration by the owner and designer, and if accepted, subsequent development by the designer.

Design Suggestion 1.
The profile on construction sections 146.30 and 146.40 has not yet been adjusted for final grades optimizing earthwork cut and fill. The team intended to make some suggested grade adjustments to this end, however did not, because of insufficient data. The team did, however, identify two areas (one in each construction section) where it appears that there is good opportunity to adjust grades for better earthwork balance.

In construction section 146.30 between stations 1317+00 and 1393+00.
In construction section 146.40 between stations 1489+00 and 1557+00.

Design Suggestion 2.
Expect to find lead base paint and asbestos in the facilities to be demolished. Line items should be included in the cost estimate to cover these potentials. Schedules need to allow for this activity.

SECTION 5 - VALIDATED ITEMS

Validated items are presented in this section. Some parts of the design were studied, that did not produce recommendations or design suggestions. In the opinion of the team, those parts of the design cannot be improved upon. In that case, the study is, in effect, validating those parts of the design. These items are listed below.

The team found very little to recommend on this project in the way of suggested improvement. This is to the credit of all involved; designers, project managers, the district engineer, and those who have been reviewing the project. The general consensus of the team is that the design was well thought out, showing no apparent errors, and few recommendations for improvement.

When a value team studies a project design, and does not find many things to recommend for improvement; this has the effect of validating those aspects of the design. If the team finds no, or few, recommendations; then it can be assumed that a second group of independent professionals, in this case the value engineering team, has come to the same conclusions as the design team, thus validating the work of the design team.

Items studied and validated.
In particular, the following items were studied, and validated by the team.

Concern and design for, environmental issues, such as; bat caves, cemeteries, archeological sites, underground tanks, and historic sites. The design alignment does a good job of avoiding these sensitive areas.

The horizontal alignment in general. Considering right-of-way, property development, road connections, keeping cross overs a minimum, and the need to remain in proximity to the old roadway; the team finds no improvements to be made in this category.

The corridor. In the area of horizontal alignment, the team also agrees with the proposed need to align the new road in the vicinity of the old road.

The vertical alignment in sections 146.01 and 146.01 was studied and validated. Because earthwork quantities for the other two sections, 146.3 and 146.4 were not available; no comprehensive study was possible on these, and therefore no conclusion can be drawn.

No improvement in the treatment of sink holes was found.

The decision to partially control the access is validated.

A good job in avoiding existing utilities.

Agree with the decision to demolish the existing bridges.

Items not studied.
Certain items were not studied, due to lack of information. These items while not the subject of VE recommendations, can not be considered validated. Items not studied include:

Drainage structures.

Vertical alignment on sections 146.30 and 146.40.

Pavement design. Unfortunately for this study there was no data on pavement design that could be studied. This is unfortunate because from the cost models it can be seen that the pavement represents by far the largest share of project cost.

APPENDICES

The appendices in this report contain backup information supporting the body of the report, and the mechanics of the workshop.

CONTENTS

APPENDIX A
Participants

Appendix A documents the persons who participated in the workshop.

Participants and Attendance

PERSONNEL				ATTENDANCE					
NAME	Organization	Role in Workshop	Telephone	Introduction Meeting	Day 1	Day 2	Day 3	Day 4	Presentation
John H. Williams	Dames & Moore	Cost. Engr.	918-446-8963	X	X	X	X	X	X
James Boddy	Dames & Moore	Geotech. Engr.	847-228-0707	X	X	X	X	X	
Joette Fields	KYTC	Design	502-564-3280	X	X	X	X	X	X
Robert Semones	KYTC	Design	502-564-328	X	X	X	X	X	X
Daryl Greer	KYTC	Design	502-564-3280	X	X	X	X	X	X
Glen Kelly	Presnell Assoc. Inc.		502-585-2222	X	X				
Phil Carter	KYDOT	Construction	502-746-7898	X	X				
Kenneth W. Cox	KYDOT	Pre. Const.	502-746-7898	X	X				X
Gary S. Poole	KYTC	Highway Design	502-564-328	X	X	X	X	X	X
Lowell S. McGowan	D & M / H&E	Engineer	502-583-2723	X	X	X	X	X	X
Jamie L. Pappas	Dames & Moore	Recorder	913-677-0023 ext. 116	X	X	X	X	X	X
John Sankey	Dames & Moore	Team Leader	913-677-0023 ext. 124	X	X	X	X	X	X

Note: Study was closed one day early because the project was found to offer minimal VE opportunity. For this reason there were 4 days in lieu of the usual 5.

APPENDIX - B
Cost Information

General
There are four cost estimates associated with this project; an overall planning estimate done by Wilbur Smith and Assoc in 1993, a designer's estimate for section 146.01 dated Oct 1996, a designer's estimate for section 146.10 dated Feb 1997, and a designer's estimate for section 146.20 of recent origin but of unknown date.

Overall Planning Estimate by Wilbur Smith and Assoc.
An overall analysis was made of the Wilbur Smith 1993 planning estimate using the three later estimates of the separate construction sections (146.01, 146.2, and 146.1) for comparison. The unit prices used in the planning estimate appear reasonable. The estimated costs found in the planning estimate appear to be significantly lower than the more recent construction section estimates. This difference continues to be significant after the planning estimate has been escalated up to present time.

The three designer's Estimates.
Nothing appeared to be out of line with these three estimates. There is no disagrement with the unit prices. There was no way to verify lump sums, such as clearing and grubbing, and bridges. There was no way to verify quantities. For these reasons the estimates could not be completely verified.

Team's Approximation of Total Overall Cost
The team developed an overall estimate of the complete project (all five sections 146.01, 146.10, 146.20, 146.30, and 146.40). Three of the five sections have been estimated for cost, two sections have not. The estimates for the three sections were used to create an average estimate for the two sections without estimates. Adding the three known estimates plus the two averaged estimates gave an approximation of the total cost of the project.

The three current estimates of the three construction segments (146.01, 146.20, and 146.10) were used to establish an average estimated cost per kilometer (the estimated cost being reduced by the amount of the bridges and the one large box culvert). This average estimated cost was then used as a multiplyer over the length of the two construction sections not currently estimated (146.30 and 146.40) to obtain an estimated cost for the two sections (146.30 and 146.40). Since the sections 146.30 and 146.40 do not contain bridges or a large box culvert, the reduced average computed from sections 146.01, 146.20, and 146.10, can be assumed to reflect a realistic measure. Based on this analysis, the team has estimated the total project at $46,716,289. The breakdown between construction sections is as follows.

Construction section 146.01 estimate = $3,994,719
Construction section 146.10 estimate = $12,301,944
Construction section 146.20 estimate = $11,098,154
Construction section 146.30 estimate = $19,321,472 (Based on a per kilometer average)

Value team estimate for total project = $46,716,289 (Total cost to the owner)

Cost Models.
The team created cost models based on the estimates to use as an aid to discover where the major portions of money were estimated to be used on the project. At the time of the study, four estimates were given to the team; an overall estimate made by Wilbur Smith and Assoc in 1993, and more current estimates of three of the five construction sections; 146.01, 146.10, and 146.20. These four estimates were used to create four cost models based on functional assembly systems on the project. Eight functional assembly systems were defined, to which a ninth catagory titled "other" was added, making a total of a nine catagory breakdown for each of the four models. The catagories used were:

1. Pavement
2. Earthwork
3. Drainage (including headwalls, and not including box culverts)
4. Stuctures (other than pipe drainage structures to include culverts, retaining walls, and bridges)
5. Erosion control
6. Mobilization / Demobilization
7. Traffic maintenance
8. Safety
9. Other

Cost Distribution Sheets were used to redistribute the estimated costs from the "construction item" breakdown of the estimate, to the "functional assembly system" breakdown of the cost model. A functional assembly breakdown is more meaniful to the value analysis than is the construction item breakdown.

The four Cost Model - Cost Distribution Sheets used to build the four cost models are shown on the following pages. The data from the distribution sheets was combined on a summary sheet to show the distribution of cost over the 9 catagories for all four estimates. From the summary sheet it can be seen that pavement accounts for almost half the project cost. Earthwork is the next big item with drainage and structures next below that. Cost distribution sheets and the corresponding summary sheet are shown later in this appendix.

Concrete Box Culvert
The team suggests that the large box culvert on project 146.10 has been underestimated. The difference of opinion is in the area of quantities.

Large concrete box culvert was estimated at $7,227,396.
2,494 CU M class A concrete.
298,794 KGRAM steel reinforcement.

Based on corrections of the quantities, the new estimate is suggested to be $6,738,683.
1,850 CU M class A concrete.
165,000 KGRAM steel reinforcement.

This is a reduction to the cost estimate of $488,533. Adding in contingencies and owner cost that reduces the VE team estimate of total cost to the owner from $49,757,928 to $46,716,289.

Gravity Retaining Wall
During the workup on idea S-1 it was noted that there is no apparant item in the designer's cost estimate for the gravity retaining wall in front of Greenwood High school.

Sink Holes.
It is thought that the effort needed to overcome sink holes is underestimated. It is suggested that the estimate be increased to cover more of this possibility.

Team Estimate of Total Project Cost.

	Construction Sections of the Project.					
Bowling Green	146.01	146.2	146.3	146.4	146.1	Scottsville
	Urban	Rural	Rural	Rural	Rural	
	First Cost: $3,994,719	First Cost: $11,098,154	No Est.	No Est.	First Cost: $12,301,944	
	90% Design	30% Design	15% Design	15% Design	30% Design	

	1st. Cost	Budget	
Section 146.01=	3,994,719	5,000,000	
Section 146.2 =	11,098,154	11,000,000	
Section 146.3 =	No Est.	7,750,000	
Section 146.4 =	No Est.		
Section 146.1 =	12,301,944	12,000,000	
	$27,394,817		1st Cost for 146.01, 146.2, 146.1 (15.68 KM)

17.7 Mile x 1.609 = 28.48 KM
We have Estimates for 15.68 KM (146.01, 146.2, 146.1)
We have no Estimates for 12.8 KM (146.3, 146.4)

($27,394,817) / (15.68 KM) = $1,747,118 $/KM for 146.3 and 146.4

($1,747,118 $/KM) x (12.8 KM) = $22,363,311 for 146.3 and 146.4

Averaged Estimate = $22,363,311 for 146.3 and 146.4

+

Known Estimates = $27,394,817 for 146.01, 146.2, and 146.1

Total Cost to Owner = $49,757,928 - Adjust to omit Bridges & Large culvert

Wilbur Smith - Alt. 1 November 1993 = 25,724,696

Nov. 93 - Mar. 97 = 41 Months.

41/12 = 3.42 Yrs. @ 3.1% = 10.6 % Escalation

25,724,696 x 1.106 = $28,451,514

Wilbur Smith Escalated to March 1997 = $28,451,514

Adjust Prices for 15.68 KM @ $27,394,817		Mob	DeMob	Eng. Cont.	
Delete Bridges @ 2,176,200	----------	3%	1.5%	15%	$2,616,375
Delete Culvert @ + 884,500	----------	3%	1.5%	20%	$1,109,640
$3,060,700					$3,726,015 Delete

Sum of 146.01 +146.20 + 146.10 = $27,394,817

Delete Bridges = $ 3,726,015

Adjusted Cost 15.68 KM = $23,668,802

($23,668,802) / (15.68 KM)= $1,509,490/KM

No Estimates for 12.8 KM

Use 1,509,490 x 12.8 = $19,321,472

Sum of 146.01 + 146.2 + 146.10 = $27,394,817

$46,716,289

Cost Distribution Sheets.

On the following sheets will be found the four cost distribution sheets used to redistribute the cost estimate from the "construction items" listed vertically in column one to the "functional" assembly/systems listed horizontally across the sheet at the top of column 3-13. The purpose of the redistribution of cost to functional assembly systems is that analyzing cost using this break down is more meaningful to the value analysis methodology than is an analysis based on construction items.

Project 146 - overall estimate (Wilbur Smith and Associates, 1993)
Distribution of costs over 10 functional assembly systems

Construction items	Amount	FUNCTIONAL ASSEMBLY / SYSTEMS									
		Pavement	Earth-work	Drainage Inc. Head walls	Structures Ret. Walls Culverts	Bridges	Erosion Control	MOB / DMOB	Traffic Maint.	Safety	Other
Clearing & Grubbing	925800										925800
Roadway Excavation	4662784.50		4662785								
Seed & Protect, Meth 2	336000						336000				
Fertilizer 10-20-20	34770						34770				
Agricultural Limestone	15120						15120				
Standard Cur & Gutter	146700	146700									
Perf Pipe - 4 Inch.	240000	240000									
Non- Perf Pipe - 4 inch.	6000	6000									
Culvert Pipe - 15 INCH	200000			200000							
Culvert Pipe - 18 INCH	56000			56000							
Culvert Pipe - 24 INCH											
Culvert Pipe - 30 INCH	81100			81100							
Culvert Pipe - 36 INCH	25220			25220							
Culvert Pipe - 42 INCH	21000			21000							
Culvert Pipe - 48 INCH											

Construction items	Amount	FUNCTIONAL ASSEMBLY / SYSTEMS									
		Pavement	Earth-work	Drainage Inc. Head walls	Structures Ret. Walls Culverts	Bridges	Erosion Control	MOB / DMOB	Traffic Maint.	Safety	Other
Culvert Pipe - 54 INCH	25300			25300							
Culvert Pipe - 60 INCH											
Culvert Pipe - 66 INCH											
Culvert Pipe - 72 INCH											
Drop Box Inlet Type 5B	76000			76000							
Droop Box Inlet Type 13G	68000			68000							
Silt Fence	2400						2400				
Silt Check	22450						22450				
Guardrail-Steel W Beam	261000										
Guardrail End Treat TY 2A	5120										
Guardrail End Treat TY 3	5500										
Guardrail End Treat TY 4	3150										
R/W Fence-Woven Wire	279600										
R/W Marker Rural TY 1	1020										
DGA Base	3997524	3997524									

Construction items	Amount	FUNCTIONAL ASSEMBLY / SYSTEMS									
		Pavement	Earth-work	Drainage Inc. Head walls	Structures Ret. Walls Culverts	Bridges	Erosion Control	MOB / DMOB	Traffic Maint.	Safety	Other
Bit. Conc Base	5560434	5560434									
Bit. Conc. Surface	1009350	1009350									
Temp Eros. Cntr. Mulch	7200						7200				
Temp Eros. Cntr. Seed	3593.70						3593.70				
Temp Eros. Cntr. Bit Mat	6600						6600				
SPCL Seed Crown Vetch	7000						7000				
Detour Const.	400000							400000			
Maintain & Cntr. Traffic	500000								500000		
Staking	500000										500000
Remove Exist Structure	500000										500000
2 Bridges @ Drakes Crk	3600000				3600000						
VAR Message Sign - Port	12000								12000		
Flashing Arrow	12000								12000		
Borrow Excavation	700000		700000								
Mobilization	729322							729322			
Demobilization	364661.04							364661.04			

Construction items	Amount	FUNCTIONAL ASSEMBLY / SYSTEMS									
		Pavement	Earth-work	Drainage Inc. Head walls	Structures Ret. Walls Culverts	Bridges	Erosion Control	MOB / DMOB	Traffic Maint.	Safety	Other
Subtotal		10960008	5362784	479620	3600000		435133	1493983	524000		1373200
Individual Percentages		48%	12%	19%	1.0%		2%	4.3%	4.4%	0%	9.2%
10% Contingencies.	2540471.93										
Total Bid	27945191.										

Construction Section 146.01 cost estimate.
Distribution of costs over 10 functional assembly systems

Construction items	Amount	FUNCTIONAL ASSEMBLY / SYSTEMS									
		Pavement	Earth-work	Drainage Inc Head walls	Structures Ret. Walls Culverts	Bridges	Erosion Control	MOB / DMOB	Traffic Maint.	Safetey	Other
Entrance Pipe-375 mm	4615			4615							
Entrance Pipe - 375 mm	750			750							
Entrance Pipe - 450 mm	1680			1680							
Culvert Pipe - 600 mm Eqv.	650			650							
Culvert Pipe - 375 mm	219562.50			219562							
Culvert Pipe- 450 mm	134162			134162							
Culvert Pipe- 600 mm	13282.50			13283							
Culvert Pipe- 750 mm	3960			3960							
Culvert Pipe- 600 mm Eqv.	2310			2310							
Slotted Drain Pipe 300 mm	6300			6300							
Metal End Section Type 3B - 375 mm	3000			3000							
Metal End Section Type 3B - 450 mm	1600			1600							
Metal End Section Type 3B- 600 mm	4000			4000							
Metal End Section Type 3B - 750 mm	1200			1200							

Construction items	Amount	FUNCTIONAL ASSEMBLY / SYSTEMS									
		Pavement	Earth-work	Drainage Inc. Head walls	Structures Ret. Walls Culverts	Bridges	Erosion Control	MOB / DMOB	Traffic Maint.	Safetey	Other
Metal End Section Type 4B - 600 mm	3000			3000							
Drop Box Inlet Type I	2000			2000							
Drop Box Inlet Type II	31500			31500							
Drop Box Inlet Type 16G	229500			22950							
Drop Box Inlet Type 16S	6600			6600							
Manhole Type C	10800			10800							
Embankment in Place	383,088		383,088								
Backfill Undercut	44000		44000								
Water	13500										13500
R/W Markers Municipal Type I	3150										3150
Clearing Sinkhole	4000			4000							
Channel Lining Class II	1896						1896				
Clearing & Grubbing	23000										23000
Concrete Class B	18240				18240						
Mobilization	45665.24							45665			
Demobilization	22832.62							22833			
Excelsior Blanket	956.40						956				
Handrail Type A-I	61200										61200
Maintain & Control Traffic	70000								70000		

Construction items	Amount	FUNCTIONAL ASSEMBLY / SYSTEMS									
		Pavement	Earth-work	Drainage Inc. Head walls	Structures Ret. Walls Culverts	Bridges	Erosion Control	MOB / DMOB	Traffic Maint.	Safetey	Other
Silt Trap Type B	4200						4200				
Removing Pavement	1980										1980
Staking - 70%	50000										50000
Subtotal from sheet 1			427088	680472	18240		7052	68498	70000		152830
Silt Fence	17750						17750				
Silt Checks	2550						2550				
Seeding and Protection Method 1	23524						23524				
Seed & Protect. Method 2	6469						6469				
Sodding	10027.50						10028				
Agricultural Limestone	1053.50						1053				
Fertilizer 10-20-20	1626						1626				
Junction Box Type B1	2000			2000	1937						
Class A Concrete	1937.1				170						
Steel Reinforcement	170										
Signalization	100000								100000		
Subtotal from sheet 2				2000	2107		62800		100000		
Mob & Dmob	58590.18 29295.09							58590 29295			
Staking	25000										25000
Maintain & Control Traffic	30000								30000		

Construction items	Amount	FUNCTIONAL ASSEMBLY / SYSTEMS									
		Pavement	Earth-work	Drainage Inc. Head walls	Structures Ret. Walls Culverts	Bridges	Erosion Control	MOB / DMOB	Traffic Maint.	Safetey	Other
DGA Base	400634	400634									
Bit. Concrete Base Classl	808800	808800									
Bit. Concrete Surface Class 1 - 40/20	137702.50	137703									
Bit. Mix for Leveling & Wedging	75237.50	75237									
Bit. Material forTack	13485.15	13485									
Standard Curb & Gutter	188712	188712									
Standard Header Curb	2736	2736									
Mountable Median Type 2	3696	3696									
Edge Key	3192	3192									
Bit. Pave Milling & Texturing	26350	26350									
Sidewalk 100 mm	151452										151452
Pavement Striping - White	846	846									
Pavement Striping - Yellow	4272.60	4272.60									
Removable Striping - White	5625								5625		
Removable Striping - Yellow	5625								5625		
Flashing Arrow	8400								8400		

Construction items	Amount	FUNCTIONAL ASSEMBLY / SYSTEMS									
		Pavement	Earth-work	Drainage Inc. Head walls	Structures Ret. Walls Culverts	Bridges	Erosion Control	MOB / DMOB	Traffic Maint.	Safetey	Other
Pavement Marker Type V M W	8070	8070									
Pavement Marker Type V B Y	12675	12675									
Cem Conc. Entrance Pavement - 8-inch	40495	40495									
Sub-total Individual		1726903						87885	49650		176452
Individual Total		1726903	427088	680471	20347		69852	156382	156650		329282
Percent of Total Cost		48%	12%	19%	1.0%		2.0%	4.4%	4.4%		9.2%
Sub total Surfacing	2040891.02										
Sub-Total	3631563.48										
10% Engr.& Contg.	363156.00										
Grand Total	3994719.48										

Construction Section 146.10 cost estimate.
Distribution of costs over 10 functional assembly systems

Construction items	Amount	FUNCTIONAL ASSEMBLY / SYSTEMS									
		Pavement	Earth-work	Drainage Inc. Head walls	Structures Ret. Walls Culverts	Bridges	Erosion Control	MOB / DMOB	TrafficMaint.	Safety	Other
Bit. Concrete Surface Class I-0	49559.10	49559.10									
Bit. Concrete Base Class I	97890.21	97890.21									
Crushed Stone Base	146255.16	146255.16									
Bituminous Material For Tack	1179.08	1179.08									
Roadway Excavation	3256244		3256244								
Clear, and Grub (56 Hect)	140000										140000
Staking	70000										70000
Seed and Protect,Method 2	137954.60					137954.60					
Agricultural Limestone	7541.14					7541.14					
Fertilizer 10-20-20	13145.28					13145.28					
Fertilizer 20-10-10	5423.2					5423.2					
R/W Fence-Woven Wire	173454.5										173454.5
Culvert Pipe- 450 mm	78400		78400								
Culvert Pipe- 600 mm	51300		51300								
Culvert Pipe- 750 mm	54360		54360								
Culvert Pipe- 900 mm	31680		31680								

Construction items	Amount	FUNCTIONAL ASSEMBLY / SYSTEMS									
		Pavement	Earth-work	Drainage Inc. Head walls	Structures Ret. Walls Culverts	Bridges	Erosion Control	MOB / DMOB	TrafficMaint.	Safety	Other
Culvert Pipe- 1350 mm	27200		27200								
Drop Box Inlet Type 5A	36800		36800								
Metal End Section TY 3 - 450 mm	13720		13720								
Metal End Section TY 3 - 600 mm	6524		6524								
Metal End Section TY 3 - 750 mm	15200		15200								
Metal End Section TY 3 - 900 mm	16020		16020								
Metal End Section TY 3 - 1350 mm	7230		7230								
Concrete- Class A	947720			947720							
Steel Reinforcement	328673.4			328673.4							
Maintain and Control Traffic	50000								50000		
Mobilization	172904.21							172904.21			
Demobilization	86452.11							86452.11			
Subtotal	6022829.99										
20% Eng. & Cont.	1204566										
Total Bid	7227395.99										
Bit. Concrete Surface Class I-0	412440	412440									
Bit. Concrete Base Class I	1601040	1601040									

Construction items	Amount	FUNCTIONAL ASSEMBLY / SYSTEMS									
		Pavement	Earth-work	Drainage Inc. Head walls	Structures Ret. Walls Culverts	Bridges	Erosion Control	MOB / DMOB	TrafficMaint.	Safety	Other
Crushed Stone Base	1619745	1619745									
Bituminous Material For Tack	29028	29028									
Bit Conc Binder Class I-0	467310	467310									
Final Dressing Class B											
Bituminous seal Aggregate	26040	26040									
Emulsified Asphalt RS - 2	27000	27000									
Maintain and Control Traffic									50000		
Guardrail - Steel W/Beam Face											
Guardrail End Treatment											
Pavement Striping Perm 100 mm	2154	2154									
Pavement Marker TY V-MW	15000	15000									
Mobilization	133088.07										
Demobilization	66544.04										
Sub total	4635901.11	4494640.55	3256244	338434	1276393.4	164064.		458988	100000		407866
Individual percentage		42%	31%	3.0%	12%	1.5%		4.3%	0.9%	1.5%	3.8%
20 % Eng & Cont.	5563081.33										

Construction Section 146.20 cost estimate.
Distribution of costs over 10 functional assembly systems

Construction items	Amount	FUNCTIONAL ASSEMBLY / SYSTEMS									
		Pavement	Earth-work	Drainage Inc. Head walls	Structures Ret. Walls Culverts	Bridges	Erosion Control	MOB / DMOB	Traffic Maint.	Safety	Other
Clear & Grubbing (47 ha)	60000										60000
Embankment in Place	2100000		2100000								
Seed and Protect Method 2	55000						55000				
Agricultural Limestone	4180						4180				
Fertilizer 10-20-20	9240						9240				
Fertilizer 20-10-10	4620						4620				
Silt Check	9280						9280				
Channel lining Class III	54000						54000				
R/W Fence-Woven Wire	27000										27000
Remove Exist Structure 146 m	60000										60000
Remove Exist Structure 64 m	25000										25000
Bridges 4 ea. Total 3348 sm	2176200				2176200						
Sodding	29520						29520				
Guardrail - Steel W/Beam S Face	96000										
Guardrail - Steel W/Beam D Face	2300										
Guardrail con to BR end Type A	3600										

Construction items	Amount	FUNCTIONAL ASSEMBLY / SYSTEMS									
		Pavement	Earth-work	Drainage Inc. Head walls	Structures Ret. Walls Culverts	Bridges	Erosion Control	MOB / DMOB	Traffic Maint.	Safety	Other
Guardrail con to BR end Type A-1	1200										
Guard rail End Treatments	8000										
Removing Pavement	8750										8750
Island curb and gutter	1050	1050									
Flashing Arrow	4000								4000		
Remove Pavement Marker TY V	2475	2475									
Pavement Striping 102mm PERM	15600	15600									
Pavement Striping 102mm TEMP	1200								1200		
Removable Marker Tape - White	8000								8000		
Removable Marker Tape - Yellow	8000								8000		
Pavement Marker Type IV-BY	1050	1050									
Pavement Marker Type V-BY	6080	6080									
Pavement Marker Type V-MW	16064	16064									
Pavement Marker Type VI-MW	675	675									
Curb box Inlet Type B	10000			10000							
Drop Box inlet Type 5B	25200			25200							

Construction items	Amount	FUNCTIONAL ASSEMBLY / SYSTEMS									
		Pavement	Earth-work	Drainage Inc. Head walls	Structures Ret. Walls Culverts	Bridges	Erosion Control	MOB / DMOB	Traffic Maint.	Safety	Other
Culvert Pipe- 375 mm	25200			25200							
Culvert Pipe- 450 mm	44000			44000							
Culvert Pipe- 600 mm	21000			21000							
Culvert Pipe- 750 mm	11800			11800							
Culvert Pipe- 900 mm	16000			16000							
Entrance Pipe - 375 mm	8250			8250							
Entrance Pipe - 450 mm	5400			5400							
Entrance Pipe - 600 mm	4250			4250							
Metal End Section 3B - 375 mm	5250			5250							
Metal End Section 3B - 450 mm	8800			8800							
Metal End Section 3B - 600 mm	5000			5000							
Metal End Section 3B - 750 mm	5600			5600							
Plugging Pipe	7200										7200
Staking	90000										90000
Maintain and Cntr. Traffic	75000								75000		
Sub total grade & drain	5166034										
PCC pavement -8 inch non- reinf	4700	4700									
Bit. Concrete Surface Class I-40/20	358400	358400									

Construction items	Amount	FUNCTIONAL ASSEMBLY / SYSTEMS									
		Pavement	Earth-work	Drainage Inc. Head walls	Structures Ret. Walls Culverts	Bridges	Erosion Control	MOB / DMOB	Traffic Maint.	Safety	Other
Bit. Concrete Base Class I	1814400	1814400									
Bit. Mix for Leveling & Wedging	10800	10800									
DGA Base	1820000	1820000									
Bituminous Seal Aggregate	11000	11000									
Emulsified Asphalt RS-2	20460	20460									
Bit. Mat for Tack	27000	27000									
Traffic Bound Base	2200								2200		
Subtotal Surfacing	4068960										
Individual Subtotals		4109754	2100000	195750	2176200		165840	415574	98400		297950
Mob	277049							277049			
DMob	138524							138524			
Individual Percentages		43%	21.7%	2%	22.5%		1.7%	4.0%	1.0%	1.2%	2.9%
Sub-total	9650568										
15% Engr. & Contg.	1447585										
Grand Total	11098154										

Cost Models.

In the table below will be found four cost models for this project. The functional assembly system breakdown is listed in the leftmost column of the table. The cost models are shown in the next columns 2 - 5. The models show the breakdown of four cost estimates into the functional assembly systems, showing both dollar amounts and percentages. From the cost models, the assemblies can be identified that contribute the most cost to the project.

Cost Models

General Cost Categories

	Model 1	Model 2	Model 3	Model 4
	Overall Project	146.1 Section	146.2 Section	146.01 Section
Pavement	10,960,008 43%	4,494,640 42%	4,109,754 43%	1,726,903 48%
Earthwork	5,362,784 21%	3,256,244 31%	2,100,000 21.7%	427,088 12%
Drainage - Head wall	479,620 2%	338,434 3%	195,750 2%	680,471 19%
Structure	3,600,000 14%	1,276,393 12%	2,176,200 22.5%	20,347 1%
Culvert				
Retaining wall				
Bridges				
Erosion Control	435,133 2%	164,064 1.5%	165,840 1.7%	69,852 2%
Mob/DMob	1,493,983 6%	458,988 4.3%	415,575 4%	156,382 4.4%
Traffic Maintenance	524,000 2%	100,000 0.9%	98,400 1%	156,650 4.4%
Other	2,206,420 9%	407,866 3.8%	277,950 2.9%	329,282 9.2%
Safety	274,770 1%	162,100 1.5%	111,100 1.2%	0 0%
TOTALS	24,503,498 99.91%	10,658,729 100%	9,650,569 100%	3,566,975 100%

Appendix C
Function Analysis

As a means for stimulation creative ideas, function of certain project components are studied.

Shoulder (Used in urban and rural areas)
Allow Stopping
Allow Recovery
Allow Maintenance

Median
Separate Traffic
Avoid Accidents
Allow Recovery
Drain Road
Add Right-of-Way
Make future Right-of-Way
Allow Future-Widening

Curb & Gutter (Used in urban areas)
Reduces Right-of- Way
Removes Ditch (Slope / Back Slope)

Subase

Distribute Load	B
Drains Subsurface	B
Protects Wearing Surface	S
Reduces pumping	S
Reduces Leaching	S

APPENDIX D
Creative Idea List and Evaluation

On the following pages is the list of creative ideas developed by the team. From these ideas was generated the recommendations. Each creative idea is identified by a unique ID number. The subsequent recommendations bear the same ID number corresponding to the creative idea from whence the recommendation came.

Also shown is the numerical value of the assumed potential of the idea prior to development. Those ideas given high potential values were chosen for development into recommendations.

ID	IDEA	Potential	Developed
B-1	Do 1 Bridge in Lieu of 2 Bridge in one direction. (4 lane rural section). Combine the 2 bridges in a single direction. Two bridges overall in lieu of four bridges overall. *Later dropped because hydraulics did not work. See Appendix for explanation.*	6	D *(later dropped)*
B-2	Reuse existing Bridges		
B-3	Replace large box culvert in section 146.1 with bridge.		
B-4	Do "2 ea" 4-driving lanes 2 shoulders (5-lanes overall) Bridges in lieu of "4 each" 2 lanes, 2 shoulders (2 lanes overall) Bridge. [12' outside shoulder, 6' inside shoulder]. Change from 40' median rural section and use a narrower template (urban section with shoulders and w/o curb and gutter and with 14' paved median) from Bowling Green through the bridges over drakes creek.	7	D *(later dropped)*
B-4A	Same as B-4 except a jersey barrier is added to the paved median.	7	D
D-1	Eliminate Head walls and extend pipe.	5	D
E-1	Roll the Grade to increase excavation and decrease fill for sections 146.1, 146.3, and 146.4. *This idea was selected for development. During development it was discovered that the data that was assumed to be available had not been created. Development was then dropped.*	6	D
E-2	Have less cut and fill by altering profile. *Eliminated because it is same as E-1*		
E-3	Use narrower template & Jersey Barrier median through R. Valley with fill. *This idea was combined with B-4 during development.*		
G-1	Change Alignment at Alventon. Go south of town		
G-2	Continue 5 lane urban section out past the bridges over Drakes Creek. *This idea was combined with B-4 during development.*		

G-3	'Use New Alignment, but use "2 each" 12ft. Driving Lanes and "2 each" 10ft. Shoulders. Add truck climbing lanes. Do this in lieu of 4 lanes and 4 shoulders.		
P-1	Add perforated pipe in urban section for drainage. Substitute crushed stone subase for DGA subase.	6	D
P-2	Eliminate Curb & Gutter in urban section. Use ditch.		
P-3	Don't Pave Shoulders, Use Gravel or grass	1	
P-4	Full Depth Asphalt. Use drainage course on lime stabilized subgrade.	1	
ROW-1	Use curb and gutter around Sub-Divisions in lieu of ditch		
ROW-2	Eliminate Ditches. Just let water run off pavement.		
ROW-3	Lower grade - Reduce side slope fills. *This idea was combined with E-1 during development.*		
ROW-4	Change Access control from limited Control to "By Permit" control. Eliminate the frontage road.	2	
ROW-5	Use Jersey Barrier-median. *This idea because part of B-4.*		
ROW-6	Reduce/Eliminate Clear Zone. use Barrier instead.		
ROW-7	Achieve Limited reduction of Right of Way in critical areas for specific purposes.		
ROW-8	Use Steeper slopes with guardrail		
ROW-9	Reduce pavement width. Change from 12' lanes to 11' lanes.		
ROW-10	Use Retaining Walls. *This is a specific application of ROW-7*		
S-1	Small Std. Gravity wall in front of Greenwood High school. Replace with Mod Block retaining wall.	3	D
SH-1	Eliminate the Box that is usually used over the sink hole and just fill in sink hole with boulders. Run the drainage pipe out from the boulders to allow water to escape from the sink holes..		

SH-2	Bridge Sink hole with concrete bear s & reduce the amount of fill needed to bridge over the sink hole. (This is an environmentally conscious idea because it minimizes the amount of contamination that is put into the sink hole).		
SH-3	Mud jacking access to fill in top of sink hole.		
SH-4	Use Reinforced embankment with geo-grid to bridge sink holes.		

APPENDIX E
Other Information Generated During the Workshop

Project Drivers

Those things that are causing the project to be configured as it is.

Project Drivers that initially caused the project.

- Horizontal Alignment of the existing US 231
  - Many sharp and twisting turns. A winding road making it almost impossible to pass.
- Vertical Alignment of the existing US 231
  - Continuous hills and valleys making it almost impossible to pass.
- Inadequate typical section on existing US 231
  - Inadequate shoulder width/ inadequate Lane width) on US 231.
- Increased traffic on existing US 231.
- Accidents on US 231.
  - The design speed on the existing roadway Us-231 is 20mph, however, commuters drive 60 mph. This is a probable cause of accidents.

Project Drivers that influenced the typical section used in the new design.

- Increased Traffic on US 231.
- Danger/Accidents on US 231.
- Safety (inadequate shoulder width/ inadequate Lane width) on US 231.
- Inadequate Typical section

Project Drivers that influenced the horizontal alignment used in the new design.

- Land use.
  - Expensive Development.
  - Property values
  - Subdivisions
- Wetlands locations.
- Utilities locations.
  - Gas lines.
- Archeological sites.
- Road connections/ access limitations. Roads that must connect to new highway.
- Sink holes
- Historical sites - Things that are on the National Register, or things that are proposed to be on the National Register.
- Design speed.
- Bat caves.

Project Drivers that influenced the vertical alignment used in the new design

- Road connections/ access limitations. Roads that must connect to new highway.
- Earthwork balance of cut and fill.

Site distance criteria.
Design speed.
Sink holes

What are the various ways to create a wearing surface?

Wearing Surface	Binder	Base	Subase
Bituminous	Bit	Bit	Crushed Stone
PCC	none	DGA	Crushed Stone
Dirt			
Gravel			
Steel Grate			

Design Deficiency
Pavement Drainage in Urban section (curb/gutter)
No subase drainage is present.
Need to add a subase drainage system.
- Perforated Pipe
- Fin Drain
- Aggregate Drain

Primary Cost Items
Pavement
Earthwork
Drainage -including head walls
Structure
- culvert
- retaining wall
- bridges

Erosion Control
Mob/Dmob
Traffic Maintenance

Major Physical Components of the Roadway.
Shoulders
Driving lanes
Medians
Ditches
Turn lane
Clear zone
Curb & Gutter w/storm sewers
Road intersections.
Right of Way

APPENDIX F
Recommendation B-1

Recommendation B-1 was to incorporate the combination of the two bridges over Drake's Creek into one bridge. Both the existing roadway, and the proposed design utilize two bridges in series over Drake's Creek, one for the main channel, and one for the overflow channel. This idea was to be developed into a recommendation. During development, the hydraulic calculations did not prove out, and the recommendation was dropped. On the following pages is documented the analysis used for this recommendation. This is included for the benefit of those who might want to better understand why this idea did not work.

The existing US-231 crosses Drake's Creek by means of a 146m bridge for the main channel and a 64m bridge for an overflow channel. These bridges are noted for scour in their inspection reports. Therefore the replacement crossing shouid have equal or better hydraulics. Although the allowable backwater for the 100 year storm is 0.03 meters, the crossing, backwater should be limited to 0.23 meters which the existing will create.

The proposal was to combine the two bridges into one 210 meter bridge. This crossing would create 0.39 meters of backwater. This 0.17 meter increase in backwater would also result in an increase in velocity through the bridge with a resulting increase in scour potential. This would require a channel charge near the overflow channel.

This Value Engineering review concludes that the crossing as designed is a cost effective alternate. The hydraulics for this recommendation will not work out, therefore this recommendation is dropped. The next pages contain the rest of this analysis.

UNDERWATER INSPECTION

Transportation Cabinet
Division of Maintenance

TC 71-113
Rev. 12 89

DATE 8-15-95

BRIDGE INSPECTION REPORT

Reviewed By: JRW

Date 9-22-95

Two-Yr	✓	Substd	

Project No. 03-MP-114.0231-B0015 Milepoint 005.557

Location: 5.55 miles North of Allen/Warren Co. line over Drake Creek

Structure Description 1-188.0' Cont. Mult. T-Beam span & 6-50.0' Simple T-Beam Span

Inspector's Signature [signature] Date 8-15-95

58.	DECK	7
1	Structural Condition	7
2	Wearing Surface	6
3	Joints Clean & reseal	5
4	Drains Clear - sweep	6
5	Expansion Devices	7
6	Curbs, Sidewalks, Medians Normal	7
7	Railings Weathering	7
8	Lighting &/or Utilities	N/A

59	SUPERSTRUCTURE	5
1	Stringers, Girders, Beams	5
2	Floor Beams	N/A
3	Trusses - Main Members	N/A
3a	Trusses - Bracing, Portals	N/A
4	Bearing Devices	5
5	Alignment/Structural Members	6
6	Deflection/Vibration under load	6
7	Debris on Members	7

59A	PAINT CONDITION	3
Color: Blue	Date Painted: 1980	

60	SUBSTRUCTURE	6
1	Abutments, Wingwalls	8
2	Piers &/or Bents	6
3	Alignment &/or Settling	8
4	Scour, Erosions	6
5	Debris on Seats, Caps	6
6	Protection Systems	N/A

61.	CHANNEL/CHANNEL PROTECTION	5
1	Channel Scour	6
2	Embankment Erosion	7
3	Drift submerged in bridge limits	5
4	Channel Alignment	6
5	Vegetation spray R/W	5
6	Erosion Control System	N/A
7	Rip-Rap	N/A

62.	CULVERT & RETAINING WALLS	N/A
1	Barrel	
2	Wingwalls, Headwall	
3	Debris	

10. INVENTORY ROUTE VERTICAL CLEARANCES

Over 99 ft. 99 in.

Under 00 ft. 00 in.

36. TRAFFIC SAFETY: 0 0 0 0

71.	WATERWAY ADEQUACY	8
72.	APPROACH ROADWAY ALIGNMENT	7

113. SCOUR CRITICAL BRIDGE RATING	6
REMARKS: Not Evaluated	

108. WEARING SURFACE / PROTECTIVE SYSTEM

TYPE 3 MEMBRANE 0 PROTECTION 0

OVERLAY NO ☐ YES ☑ DATE 1983

TYPE: LATEX ✓ P.C.C. ___ ASPHALT ___

DEPTH OF ASPHALT N/A

RECOMMENDED LOAD CAPACITIES (tons) I ___ II ___ III ___ IV ___ GROSS ___

FIELD POSTINGS N E ___ S W ___ I ___ II ___ III ___ IV ___ GROSS ___

ITEM	ADDITIONAL COMMENTS
59	All beams have areas of flaky rust w/ slight pitting in various locations, mostly @ slab joints, due to H2O leakage through. An area approx. ___ in length of heavy deterioration and moderate pitting noted on lower flange @ mid span of beam E3 - span #3 and on beams "3" - "5" #7 (L.C.) [illegible]

Inspection Of Bridge Substructure Elements Affected By Water

Category Of Inspection: IA ______ IIA ______ IIIA ______; IB ______ IIB ✓ IIIB ______

Complete Description Of Method Used For Inspection: Visual & probing w/ line rod

Access Method: Walking & wading

Elements Inspected: *(Use Numbering System As Outlined In AASHTO Manual)* Abutments # 1 & # 9 piers #'s 1, 2, 3, 4, 5, 6, 7 & 8

Description Of Stream Bed Condition: Stream flows over loose gravel & mud within Bridge

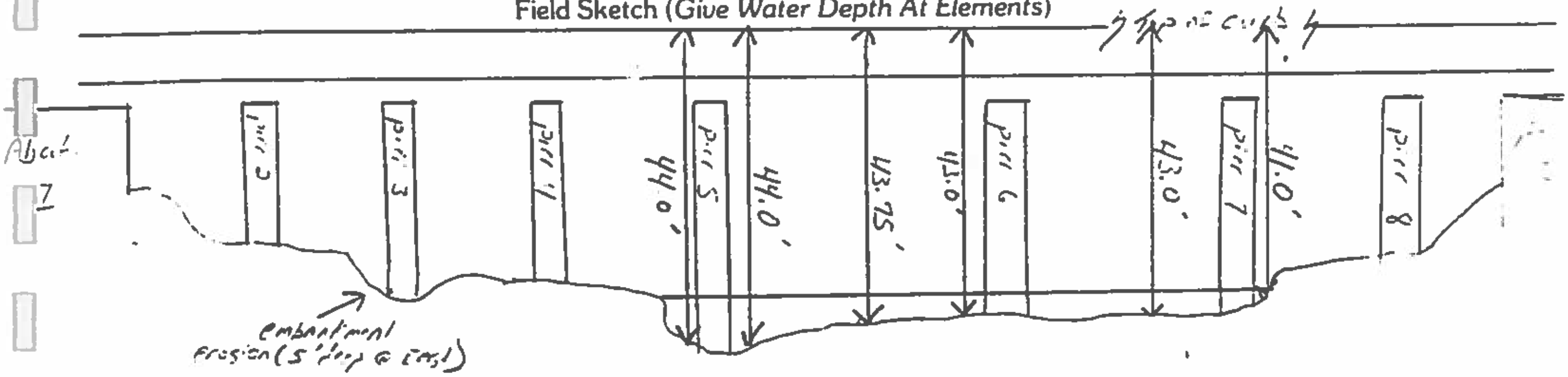
Condition Of Elements: *(If Condition Rating Is Less Than 5 Comment Required)*

60.	SUBSTRUCTURE	6
1.	Abutments, Wingwalls (From Splash Zone Down)	8
2.	Piers &/or Boats (From Splash Zone Down)	6
3.	Alignment &/or Settling Due to Scour/Erosion	8
4.	Scour, Erosion	6

62.	CULVERTS & RETAININGWALLS	N/A
1.	Scour Under Footings	
2.	Erosion At Wingwalls	
3.	Drainage Adequacy	

← To Allen Co. line (measurements @ outlet – intermediate measurements between piers taken @ 10.nt)

Field Sketch (Give Water Depth At Elements)



ITEM	ADDITIONAL COMMENTS:
59.1 (Cont)	Joint leakage has caused heavy rust staining and L.O.S. on most
59.4	diaphrams - watch closely. All bearing devices have L.O.S. due to [illegible]
59.5	rust caused by joint leakage. The horizontal misalignment of beam #2
	in span #7 checked - no change. Also noted was slight vertical misalignment
	of beam #5 in span #2 - watch.
60.2	All piers have random small spalls some w/ exposed [illegible] noted.
	Heavy deterioration [illegible] & #7 [illegible] East end and heavy [illegible]
	w/ [illegible] noted - monitor [illegible]
	[illegible] bearing [illegible] #2's stability will be [illegible] w/ any further

TYPE INSPECTION Bi-annual DATE 8-15-93

PROJECT NO. 03-MP-114-0331-130015

ITEM	ADDITIONAL COMMENTS (Cont.):
61.2	Heavy embankment erosion noted within bridge limits due to
	field drainage. Watch closely @ east side of base of
	pier #3, erosion has cut into the embankment 5' deep
	at the location. Watch erosion on North side of pier
	#8 due to roadway runoff erosion.
61.1	Watch channel scour @ outlet of pier #5 (between column #2
	and the attached stream guide span) a local scour hole
61.2 : 4	has formed @ the location (3½' deep). Stream has cut behind
	pier #5 and pier #7 watch.
58.1 - 59.6	Deck slabs are still jumping and shifting top of beams
	under heavy loading. Caused by void created between deck
	and top flanges of beams, and by slight vertical curve
	in beam. (due to dead load)
58.2	Extensive exposed Aggregate noted throughout wearing surface,
	one transverse noted @ joint #2 / span #2, in NB
	lane - watch.

UNDERWATER INSPECTION

DATE 8-16-95

Transportation Cabinet
Division of Maintenance

TC 71-1??
Rev. 12 ??

BRIDGE INSPECTION REPORT

Reviewed By: [signature]

Date 9-22-95

Two-Yr	✓	Substd	

Project No. 03-MP-114-0231-B0014 Milepoint 005.768

Location: 5.76 miles North of Allen / Warren Co. line

Structure Description 7-30.0' R.C.D.G. Spans

Inspector's Signature [signature] Date 8-16-95

58	DECK	8
1	Structural Condition	8
2	Wearing Surface	7
3	Joints	6
4	Drains Clean & Survey	7
5	Expansion Devices	N/A
6	Curbs, Sidewalks, Medians	6
7	Railings	6
8	Lighting &/or Utilities	N/A

59	SUPERSTRUCTURE	7
1	Stringers, Girders, Beams	8
2	Floor Beams	N/A
3	Trusses - Main Members	N/A
3a	Trusses - Bracing, Portals	N/A
4	Bearing Devices	N/A
5	Alignment/Structural Members	8
6	Deflection/Vibration under load	7
7	Debris on Members	7

59A	PAINT CONDITION	N/A
Color	Date Painted:	

60	SUBSTRUCTURE	8
1	Abutments, Wingwalls	8
2	Piers &/or Bents	8
3	Alignment &/or Settling	8
4	Scour, Erosions	6
5	Debris on Seats, Caps	7
6	Protection Systems	N/A

61	CHANNEL/CHANNEL PROTECTION	7
1	Channel Scour	7
2	Embankment Erosion	6
3	Drift	8
4	Channel Alignment	8
5	Vegetation	7
6	Erosion Control System	N/A
7	Rip-Rap	N/A

62	CULVERT & RETAINING WALLS	N/A
1	Barrel	
2	Wingwalls, Headwall	
3	Debris	

10. INVENTORY ROUTE VERTICAL CLEARANCES

Over 99 ft. 99 in.

Under 00 ft. 00 in.

36. TRAFFIC SAFETY: 0 0 0 0

71.	WATERWAY ADEQUACY	7
72.	APPROACH ROADWAY ALIGNMENT	7

113. SCOUR CRITICAL BRIDGE RATING	6
REMARKS: Not Evaluated	

108. WEARING SURFACE / PROTECTIVE SYSTEM

TYPE 3 MEMBRANE 0 PROTECTION 0

OVERLAY NO ☐ YES ☑ DATE ____

TYPE: LATEX ✓ P.C.C. ___ ASPHALT ___

DEPTH OF ASPHALT NA

RECOMMENDED LOAD CAPACITIES (tons) I ____ II ____ III ____ IV ____ GROSS ____

FIELD POSTINGS N E ___ S W ___ I ____ II ____ III ____ IV ____ GROSS ____

ITEM	ADDITIONAL COMMENTS
58.2	Some cracks (map cracking) and spalled areas noted along wearing surface.
59.1	Watch patch on girder #2 over pier #1 - slight rust stain on flange.
60.4	The stream bed is [illegible] @ base of [illegible] Head

Inspection Of Bridge Substructure
Elements Affected By Water

Category Of Inspection: IA _____ IIA _____ IIIA _____ ; IB _____ IIB ✓ IIIB _____

Complete Description Of Method Used For Inspection: Visual & probing w/ line rod

Access Method: Walking

Elements Inspected: *(Use Numbering System As Outlined In AASHTO Manual)* Abutments #1 + #8

Piers # 2, 3, 4, 5, 6 + 7

Description Of Stream Bed Condition: Bridge is over wet weather / overflow stream only channel is natural ground w/ heavy vegetative growth. Channel is dry @ this time

Condition Of Elements: *(If Condition Rating Is Less Than 5 Comment Required)*

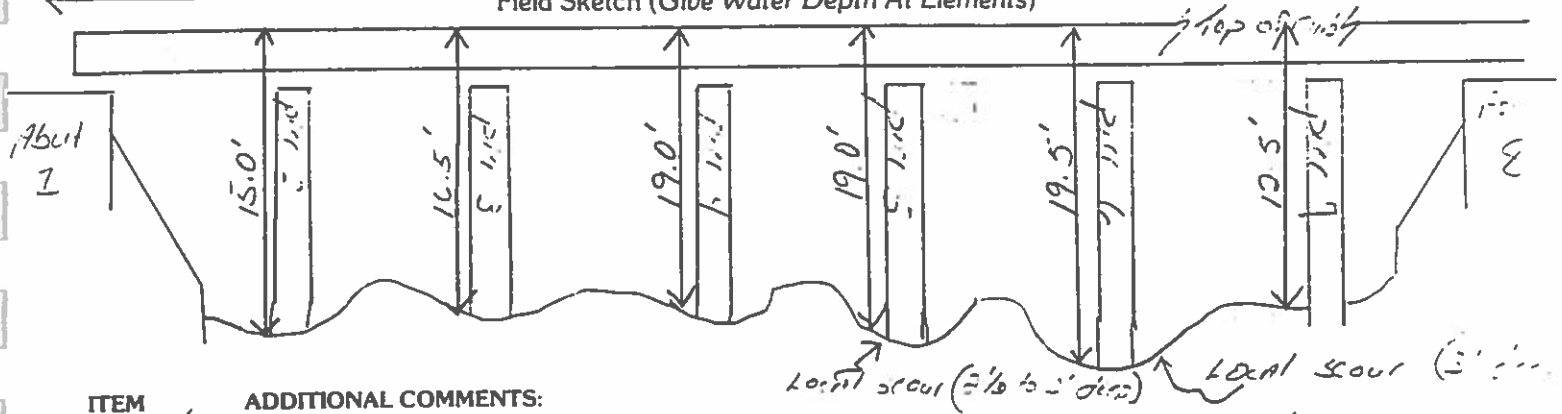
60.	SUBSTRUCTURE	8
1.	Abutments, Wingwalls (From Splash Zone Down)	8
2.	Piers &/or Boats (From Splash Zone Down)	8
3.	Alignment &/or Settling Due to Scour/Erosion	8
4.	Scour, Erosion	6

62.	CULVERTS & RETAININGWALLS	N/A
1.	Scour Under Footings	
2.	Erosion At Wingwalls	
3	Drainage Adequacy	

(Measurements taken @ East side @ All piers)

To Allen Rd line

Field Sketch (Give Water Depth At Elements)



ITEM	ADDITIONAL COMMENTS:
60.4 (cont)	local scour is NOT affecting bridge but should be monitored closely.
58, 6 + 60.1	some random areas of slight LOS. due to scaling concrete no exposed steel - no repairs.

KWSPRO : KENTUCKY TRANSPORTATION CABINET VERSION - WSPRO (HY-7)
KY2401 FLOODWAY ANALYSIS MODEL

Run Date & Time : 3- 5-1997 12:24

EXISTING & proposed MAIN LINE + OVERFLOW

T1 1 WARREN COUNTY US 231 TWIN BRIDGES OVER DRAKES CREEK

146 m
64 m

(-- Cross Section "FLODA" Written to Disk, Record No. = 1
(-- Cross Section "FLODB" Written to Disk, Record No. = 2
(-- Cross Section "PEXIT" Written to Disk, Record No. = 3
(-- Cross Section "PFULV" Written to Disk, Record No. = 4
(-- Cross Section "BRDGE" Written to Disk, Record No. = 5
(-- Cross Section "ROAD " Written to Disk, Record No. = 6
(-- Cross Section "PAPPR" Written to Disk, Record No. = 7
(-- Cross Section "EAPPR" Written to Disk, Record No. = 8
(-- Cross Section "FLODC" Written to Disk, Record No. = 9

<<=== NORMAL PROFILE ==== NO. 1 ===>>

XSID:CODE	SRDL	LEW	AREA	VHD	HF	EGL	CRWS	Q	WSEL
	m	m	m)	A	m	m	m	m/s	m
SRD	FLEN	REW	K	ALPH	HO	ERR	FR#	VEL	
m	m	m	m/s		m			m/s	
FLODA:XS	******	337.4	1140.5	.29	*****	145.10	142.76	2259.9	144.89
.0	******	699.3	30950.1	1.41	*****	*****	.43	1.00	
FLODB:XS	445.0	73.3	1705.1	.13	.29	145.47	*******	2259.9	145.34
445.0	360.0	800.6	93766.2	1.48	.00	-.01	.32	1.30	
PEXIT:XS	240.0	84.0	2107.3	.08	.09	145.56	*******	2259.9	145.48
685.0	213.1	937.7	119244.4	1.35	.00	.00	.24	1.06	
PFULV:FV	145.0	81.8	2554.0	.05	.02	145.58	*******	2259.9	145.50
830.0	96.7	990.5	154224.4	1.34	.00	-.00	.19	.88	
PAPPR:AS	175.0	269.2	2093.1	.08	.01	145.60	*******	2259.9	145.54
1005.0	159.5	795.8	134393.3	1.31	.01	.00	.20	1.08	

<<== END OPEN CHANNEL FLOW ==>>

(--105 Conveyance Ratio Outside Recommended Limits.
"FLODB" KRATIO = 1.34

(--220 Flow CLASS 1 (4) Solution Indicates Possible PRESSURE FLOW.
WSO,WSIU,WSI,LSCL = 145.43 145.68 145.73 145.58

(--245 Attempting Flow CLASS 2 (5) Solution.

(--250 Insufficient Head for Pressure Flow.
YU/Z,WSIU,WS = 1.03 145.93 146.08

XSID:CODE	SRDL	LEW	AREA	VHD	HF	EGL	CRWS	Q	WSEL
	m	m	m)	m	m	m	m	m/s	m
SRD	FLEN	REW	K	ALPH	HO	ERR	FR#	VEL	
m	m	m	m/s		m			m/s	
RDGE:DR	145.0	569.7	1166.5	.23	.07	145.71	141.43	2259.9	145.43
830.0	145.0	955.4	89665.6	1.45	.08	.00	.43	1.91	

TYPE	PROJ	FLOW	C	P/A	LSEL	BLEN	XLAB	XRAB
					m	m	m	m
3.0	.0	1.0	.802	.049	145.58	******	******	******

XSID:CODE	SRD	FLEN	HF	VHD	EGL	ERR	Q	WSEL
	m	m	m	m	m		m/s	m
ROAD :XR	846.		(<== ROADWAY IS NOT OVERTOPPED ==>)					

XSID:CODE	SRDL	LEW	AREA	VHD	HF	EGL	CRWS	Q	WSEL
	m	m	m)	m	m	m	m	m/s	m
SRD	FLEN	REW	K	ALPH	HO	ERR	FR#	VEL	
m	m	m	m/s		m			m/s	
PAPPR:AS	144.0	265.7	2212.6	.07	.12	145.85	140.87	2259.9	145.73
1005.0	319.1	796.1	146019.8	1.23	.02	.00	.18	1.02	

M(G)	M(K)	KQ	XLKQ	XRKQ	OTEL
		m/s	m	m	m
.247	.202	116479.4	373.7	769.1	145.73

- 145.53

BRIDGE BACKWATER = .20

(<== END CONSTRICTED FLOW ==>)

XSID:CODE	SRDL	LEW	AREA	VHD	HF	EGL	CRWS	Q	WSEL
	m	m	m)	m	m	m	m	m/s	m
SRD	FLEN	REW	K	ALPH	HO	ERR	FR#	VEL	
m	m	m	m/s		m			m/s	
CAPPR:XS	33.0	265.1	2232.9	.07	.04	145.89	******	2259.9	145.82
1040.0	150.3	796.1	147936.3	1.23	.00	.00	.18	1.01	

XSID:CODE	SRDL	LEW	AREA	VHD	HF	EGL	CRWS	Q	WSEL
	m	m	m)	m	m	m	m	m/s	m
SRD	FLEN	REW	K	ALPH	HO	ERR	FR#	VEL	
m	m	m	m/s		m			m/s	
FLODC:XS	235.0	264.3	1978.4	.08	.06	145.95	******	2259.9	145.87
1275.0	205.0	767.2	124311.2	1.15	.00	.00	.20	1.14	

XSID:CODE	SRDL	LEW	AREA	VHD	HF	EGL	CRWS	Q	WSEL
	m	m	m)	m	m	m	m	m/s	m
SRD	FLEN	REW	K	ALPH	HO	ERR	FR#	VEL	
m	m	m	m/s		m			m/s	
FLODA:XS	*****	316.9	1263.9	.23	*****	145.42	140.76	2259.9	145.1
.0	*****	700.4	71895.3	1.43	*****	*******	.38	1.79	

(--135 Conveyance Ratio Outside Recommended Limits.
"FLODB" KRATIO = 1.50

FLODB:XS	445.0	62.0	1884.8	.11	.24	145.66	*******	2259.9	145.5
445.0	360.0	800.5	107558.6	1.49	.00	.00	.29	1.20	
PEXIT:XS	240.0	83.0	2295.7	.07	.03	145.74	*******	2259.9	145.67
685.0	213.1	937.3	130019.6	1.34	.00	.00	.22	.98	
PFULV:FV	143.0	92.1	2495.3	.06	.02	145.76	*******	2259.9	145.70
830.0	86.0	934.2	102767.2	1.33	.00	-.00	.19	.91	
PAPPR:AS	175.0	266.5	2194.7	.07	.04	145.80	140.87	2259.9	145.73
1005.0	159.5	796.4	144081.4	1.29	.01	.00	.13	1.03	

((== END OPEN CHANNEL FLOW ==))

(--255 Attempting Flow CLASS 3 (6) Solution.
WSSN,LSEL = 145.70 145.50

((== BEGIN CONSTRICTED FLOW ==))

XSID:CODE	SRDL	LEW	AREA	VHD	HF	EGL	CRWS	Q	WSEL
	m	m	m)	m	m	m	m	m/s	m
SRD	FLEN	REW	K	ALPH	HO	ERR	FR#	VEL	
m	m	m	m/s		m			m/s	

396.5m

BRDGE:BR	145.0	569.3	1140.0	.20	*****	145.78	141.45	2287.1	145.5
330.0	*****	965.8	30562.5	1.00	*****	*******	.07	2.00	

TYPE	PROG	FLOW	C	P/A	LSEL	OLEN	XLAB	XRAB
					m	m	m	m
3.0	.0	3.0	.800	.040	145.56	******	******	******

XSID:CODE	SRD	FLEN	HF	VHD	EGL	ERR	Q	WSEL
	m	m	m	m	m		m/s	m
ROAD :XR	946.		((== ROADWAY IS NOT OVERTOPPED ==))					

XSID:CODE	SRDL	LEW	AREA	VHD	HF	EGL	CRWS	Q	WSEL
	m	m	m)	m	m	m	m	m/s	m
SRD	FLEN	REW	K	ALPH	HO	ERR	FR#	VEL	
m	m	m	m/s		m			m/s	

PAPPR:AS	144.0	260.7	2463.8	.05	.27	146.29	140.87	2259.9	146.2
1005.0	357.2	796.4	170626.8	1.24	.02	.01	.15	.92	

M(G)	M(K)	KQ	XLKQ	ARKQ	OTEL

XSID:CODE	SRDL	LEW	AREA	VHD	HF	EGL	CRWS	Q	WSEL
	m	m	m)	m	m	m	m	m/s	m
SRD	FLEN	REW	K	ALPH	HO	ERR	FR#	VEL	
m	m	m	m/s		m			m/s	
EAPPR:XS	35.0	260.7	2478.6	.05	.03	146.32	*******	2259.9	146.27
1040.0	150.8	706.4	172182.1	1.24	.00	.00	.13	.91	

XSID:CODE	SRDL	LEW	AREA	VHD	HF	EGL	CRWS	Q	WSEL
	m	m	m)	m	m	m	m	m/s	m
SRD	FLEN	REW	K	ALPH	HO	ERR	FR#	VEL	
m	m	m	m/s		m			m/s	
FLODC:XS	235.0	259.1	2193.7	.06	.04	146.36	*******	2259.9	146.30
1275.0	205.0	765.6	146128.9	1.12	.00	.00	.17	1.03	

KWSPRO FLOODWAY TABLE

3- 5-1997 12:24

SECID	DIST	FLDWAY WIDTH	STATIONS LTLIM	STATIONS CHAN	STATIONS RTLIM	MEAN VEL.	ELEVATIONS W/O-FW	ELEVATIONS WITH-FW	RISE
	m	m	m	m	m	m/s	m	m	m
FLODA	.0	420.7	273.7	666.8	700.4	1.79	144.89	145.19	.30
FLODB	415.0	741.3	60.0	759.0	801.3	1.20	145.34	145.55	.21
FEXIT	685.0	856.5	91.7	896.0	908.2	.98	145.40	145.67	.27
DTULV	830.0	842.2	92.1	902.4	904.2	1.03	145.53	145.70	.17
BRDGE	830.0	842.2	92.1	902.4	904.2	2.00	145.43	145.58	.15
ROAD	840.5	842.2	92.1	902.4	904.2	.01	*******	*******	.00
RAPPR	1005.0	505.8	260.6	753.9	706.4	.02	145.73	146.24	.51
EAPPR	1040.0	535.0	260.6	733.9	706.4	.01	145.81	146.27	.46
FLODC	1275.0	513.0	257.3	731.4	770.9	1.03	145.87	146.30	.43

NORMAL END OF KWSPRO RUN.

KWSPRO : KENTUCKY TRANSPORTATION CABINET VERSION - WSPRO (HY-7)
Ky9401 FLOODWAY ANALYSIS MODEL

ONE BRIDGE

Run Date & Time : 3-20-1997 9:53

T1 1 WARREN COUNTY US 231 TWIN BRIDGES OVER DRAKES CREEK

210 m

(-- Cross Section "FLODA" Written to Disk, Record No. = 1
(-- Cross Section "FLODB" Written to Disk, Record No. = 2
(-- Cross Section "PEXIT" Written to Disk, Record No. = 3
(-- Cross Section "PFULV" Written to Disk, Record No. = 4
(-- Cross Section "BRDGE" Written to Disk, Record No. = 5
(-- Cross Section "ROAD " Written to Disk, Record No. = 6
(-- Cross Section "PAPPR" Written to Disk, Record No. = 7
(-- Cross Section "EAPPR" Written to Disk, Record No. = 8
(-- Cross Section "FLODC" Written to Disk, Record No. = 9

((=== NORMAL PROFILE ==== NO. 1 ===))

XSID:CODE	SRDL	LEW	AREA	VHD	HF	EGL	CRWS	Q	WSEL
	m	m	m)	m	m	m	m	m/s	
SRD	FLEN	REW	K	ALPH	HO	ERR	FR#	VEL	
m	m	m	m/s		m			m/s	
FLODA:XS	******	337.4	1143.5	.29	*****	145.13	142.76	2259.9	144.01
.0	******	699.3	60050.1	1.43	*****	*******	.43	1.98	
FLODB:XS	445.0	73.3	1785.4	.13	.09	145.47	*******	2259.9	145.04
445.0	960.0	900.6	90768.2	1.43	.00	-.01	.32	1.30	
PEXIT:XS	240.0	84.0	2137.8	.08	.09	145.56	*******	2259.9	145.41
685.0	213.1	937.7	119244.4	1.35	.00	.00	.24	1.06	
PFULV:FV	145.0	81.3	3504.0	.05	.01	145.58	******	2259.9	145.53
990.0	86.7	990.5	154224.4	1.34	.00	-.00	.19	.99	
PAPPR:AS	175.0	269.2	2093.4	.08	.01	145.63	*******	2259.9	145.51
1005.0	159.5	795.8	134895.3	1.31	.01	.00	.29	1.08	

((== END OPEN CHANNEL FLOW ==))

(--255 Attempting Flow CLASS 3 (6) Solution.
WSON,LSEL = 145.53 145.38

((== BEGIN CONSTRICTED FLOW ==))

XSID:CODE	SRDL	LEW	AREA	VHD	HF	EGL	CRWS	Q	WSEL
	m	m	m)	m	m	m	m	m/s	
SRD	FLEN	REW	K	ALPH	HO	ERR	FR#	VEL	
m	m	m	m/s		m			m/s	

```
[illegible]
   830.0 ******  965.8  57632.6  1.00 ***** *******      .20     2.00

   TYPE PPCD FLOW      C      P/A     LSEL     BLEN     XLAB     XRAB
                                        m        m        m        m
    3.0    .0  3.0   .300   .041   14[illegible].38 ****** ****** ******

  XSID:CODE      SRD    FLEN      HF     VHD      EGL      ERR        Q      WSEL
                   m       m       m       m        m               m3/s       m
  ROAD  :XR      840.          <<== ROADWAY IS NOT OVERTOPPED ==>>
-----------------------------------------------------------------------------------
XSID:CODE     SRDL     LEW       AREA    VHD      HF      EGL     CRWS        Q      WSEL
                 m       m         m2      m       m        m        m     m3/s         m
        SRD   FLEN     REW          K   ALPH      HO      ERR      FR#      VEL
          m      m       m       m3/s              m                        m/s
-----------------------------------------------------------------------------------
PAPPR:AS     144.0   263.1    2301.1    .06     .16   146.01   140.87   2259.9   145.[illegible]
     1005.0  [illegible]   796.3 154514.1   1.26     .00     -.00      .17      .98

        M(G)    M(K)        KQ    XLKQ     XRKQ     OTEL
                          m3/s       m        m        m
     ******  ******  ********  ******  ******   1[illegible].92

                                                                        = 145.5[illegible]
                                                                        ---------
                                                      BRIDGE BACKWATER =       .[illegible]

                          <<== END CONSTRICTED FLOW ==>>
-----------------------------------------------------------------------------------
XSID:CODE     SRDL     LEW       AREA    VHD      HF      EGL     CRWS        Q      WSEL
                 m       m         m2      m       m        m        m     m3/s         m
        SRD   FLEN     REW          K   ALPH      HO      ERR      FR#      VEL
          m      m       m       m3/s              m                        m/s
-----------------------------------------------------------------------------------
[illegible]:XS     35.0   2[illegible]   2[illegible]    .0[illegible]     .0[illegible]   14[illegible]  ******  2259.[illegible]   14[illegible]
     1040.0   1[illegible].3   7[illegible]   1[illegible]   1.26     .00      .00      .17      .97
-----------------------------------------------------------------------------------
XSID:CODE     SRDL     LEW       AREA    VHD      HF      EGL     CRWS        Q      WSEL
                 m       m         m2      m       m        m        m     m3/s         m
        SRD   FLEN     REW          K   ALPH      HO      ERR      FR#      VEL
          m      m       m       m3/s              m                        m/s
-----------------------------------------------------------------------------------
FLODC:XS     205.0   2[illegible]   2057.5    .07     .05   146.10  *******  2259.9   146.[illegible]
     1275.0   205.0   763.5  1[illegible]   1.14     .00      .00      .1[illegible]     1.10

===================================================================================

                  <<=== FLOODWAY PROFILE ==== NO. 2 ===>>

===================================================================================

-----------------------------------------------------------------------------------
 XSID:CODE     SRDL     LEW       AREA    VHD      HF      EGL     CRWS        Q      WSEL
                  m       m         m2      m       m        m        m     m3/s         m
         SRD   FLEN     REW          K   ALPH      HO      ERR      FR#      VEL
```

```
 LOOA:XS     ****** [illegible] [illegible] .1[illegible] ****** 145.42 [illegible] [illegible] [illegible]
        .0 ******  700.4   71875.9  1.43 ***** *******      .38     1.79

 <--135 Conveyance Ratio Outside Recommended Limits.
                          "FLODB"      KRATIO =   1.50

 LODB:XS      445.0    62.0    1884.3   .11    .24   145.66 *******   2259.9   145.55
      443.0   360.0   600.5 107558.6   1.49   .00      .00     .29     1.20

 EXIT:XS      240.0    83.0    2295.7   .07    .03   145.74 *******   2259.9   145.67
      683.0   213.1   937.0 190019.6   1.34   .00      .00     .22      .98

 FULV:FV      145.0    92.1    2495.3   .06    .02   145.76 *******   2259.9   145.70
      830.0    86.0   934.2 152767.2   1.33   .00     -.00     .19      .91

 APPR:AS      175.0   266.5    2194.7   .07    .04   145.80  140.87   2259.9   145.73
     1005.0   159.5   796.4 144081.4   1.29   .01      .00     .13     1.03

                     <<== END OPEN CHANNEL FLOW ==>>

 <--255 Attempting Flow CLASS 3 (6) Solution.
                   WS3N,LSEL =    145.70      145.33

                     <<== BEGIN CONSTRICTED FLOW ==>>

-----------------------------------------------------------------------------------------
 XSID:CODE    SRDL     LEW      AREA     VHD     HF      EGL     CRWS       Q      WSEL
                 m       m       m2        m      m        m        m    m3/s        m
       SRD    FLEN     REW        K     ALPH     HO      ERR      FR#     VEL
         m       m       m     m3/s               m                       m/s
-----------------------------------------------------------------------------------------
                  210.5 m (?)
 BRDGE:BR     145.0   755.0    1126.6   .21  ******  145.59  141.17   2259.9   145.[illegible]
      830.0 ******   965.9  57692.6   1.00 ***** *******      .20     2.02

     TYPE PPCD FLOW      C      P/A     LSEL     BLEN     XLAB     XRAB
                                           m        m        m        m
      3.0    .0  3.0   .800    .041   145.33 ****** ****** ******

    XSID:CODE      SRD    FLEN     HF      VHD       EGL       ERR        Q      WSEL
                     m       m      m        m         m               m3/s        m
  ROAD :XR       846.         <<== ROADWAY IS NOT OVERTOPPED ==>>

-----------------------------------------------------------------------------------------
 XSID:CODE    SRDL     LEW      AREA     VHD     HF      EGL     CRWS       Q      WSEL
                 m       m       m2        m      m        m        m    m3/s        m
       SRD    FLEN     REW        K     ALPH     HO      ERR      FR#     VEL
         m       m       m     m3/s               m                       m/s
-----------------------------------------------------------------------------------------

 APPR:AS      144.0   260.7    2402.5   .06    .13   146.13  140.87   2259.9   146.[illegible]
     1005.0   232.0   796.4 164263.2   1.25   .00      .01     .16      .94

       M(G)    M(K)         KQ    XLKQ    XRKQ     OTEL
                           m3/s      m       m        m
     ****** ****** ******** ****** ******   146.10

                     <<== END CONSTRICTED FLOW ==>>

-----------------------------------------------------------------------------------------
 XSID:CODE    SRDL     LEW      AREA     VHD     HF      EGL     CRWS       Q      WSEL
                 m       m       m2        m      m        m        m    m3/s        m
       SRD    FLEN     REW        K     ALPH     HO      ERR      FR#     VEL
         m       m       m     m3/s               m                       m/s
```

1340.0	130.0	706.4	145915.1	1.23	.00	.00	.16	.00	

XSID:CODE	SRDL	LEW	AREA	VHD	HF	EGL	CRWD	Q	WSEL
	m	m	m)	m	m	m	m	m/s	m
SRD	FLEW	REW	K	ALPH	HO	ERR	FR#	VEL	
m	m	m	m/s		m			m/s	
FLOOD:XS	235.0	260.0	2108.5	.06	.01	146.26	*******	2250.9	146.19
1275.0	205.0	706.2	140521.0	1.13	.00	.00	.17	1.01	

KWSPRO FLOODWAY TABLE

6-20-1997 9:00

SECID	DIST	FLOWAY WIDTH	STATIONS LTLIM	CHAN	RTLIM	MEAN VEL.	ELEVATIONS W/O-FW	WITH-FW	RISE
	m	m	m	m	m	m/s	m	m	m
FLODA	.0	426.7	273.7	666.0	700.4	1.79	144.89	145.19	.30
FLODB	445.0	741.3	60.0	709.0	801.0	1.20	145.34	145.55	.21
FEXIT	605.0	830.5	81.7	896.0	938.2	.98	145.46	145.67	.21
RTULV	800.0	912.2	92.1	902.4	994.2	1.03	145.53	145.70	.17
CRDGE	900.0	942.2	92.1	902.4	994.2	2.02	145.00	145.00	.00
ROAD	940.5	942.2	92.1	902.4	994.2	.31	*******	*******	.18
FWDSR	1005.0	503.0	260.0	750.9	706.4	.24	145.95	146.13	.18
CNTR	1040.0	505.8	260.6	753.9	706.4	.90	145.98	146.15	.17
FLODC	1275.0	510.3	257.8	701.4	770.5	1.06	146.03	146.19	.16

NORMAL END OF KWSPRO RUN.

Appendix G
Response to Recommendations

FORM 31 DEC 1996

TABLE SUMMARY OF RESULTS

Project: U.S. 231
Location: Bowling Green to Scottsville Road
Study Date: March 17-21, 1997

DESCRIPTION		PRESENT WORTH AMOUNT			BEST	DECISION		
I.D. #	Recommendation	1st cost of original design	1st cost of recommen-dation	resulting 1st cost savings (or cost)	suggest-ed best selection	designer decision	owner decision	final decision
B-4	From Dye Ford Road To South of Drakes Creek Bridge, The Roadway section will be an urban 5-lane section with shoulders.	4,459,972	4,371,100	88,872				
B-4A	Same as B-4 with the addition of a median barrier.	4,459,972	5,075,110	615,138				
D-1	Eliminate Culvert Head walls.	20,891	13,770	7,121	X			
P-1	Add perforated pipe in curb and gutter section for drainage purposes.	480,761	596,917	(116,156)	X			
S-1	Modular Block Retaining Wall at Greenwood High School.	19,388	10,296	9,092	X			

DECISION LEGEND A=Accepted AP=Accepted Parts of Recommendation AM=Accepted with Modification
FS=Further Study Required LD=Tabled for Later Decision R=Rejected

END OF REPORT