1. Cut section from Station 96/00 to 105/00

Backslopes

The Brady Creek shale, Middleburg limestone, Hooser shale, Kiss limestone and Stearns shale may be encountered in the ditch sections of the shallow backslopes through this location. The mantle, which overlies these shale and limestone units, consists of a silty clay that varies in thickness from one to four feet.

At station 98/10, a normal fault crosses centerline with a displacement of approximately five feet. A few hundred feet from this location, in the Tuttle Creek spillway, the fault displacement is twenty-two feet.

The reason for the difference in displacement between these two locations is that the bedrock layers were bent, as well as faulted, in the vicinity of centerline which reduced the amount of displacement of the fault. The bending of the bedrock was facilitated by the strong local dip that existed prior to faulting. The reduction of fault displacement is a local situation, since displacement is regained eastward along the fault zone.

The strong dip and faulting will not affect the proposed roadway.

Backslopes of 2:1 or flatter are suggested for the mantle.

The Brady Creek shale that will be encountered has weathered to common excavation. Backslopes of 1½:1 or flatter are suggested for this shale formation.

Backslopes of ½:1 are suggested for the Middleburg limestone member.

Backslopes of 1:1 for common excavation, and ½:1 for rock excavation are suggested for the Hooser shale member.

Backslopes of ½:1 will stand satisfactorily for the Kiss limestone member.

Backslopes of 1:1 or flatter will stand satisfactorily for the weathered Stearns shale formation that will be encountered.

Rock Excavation

The shale zones in the Brady Creek shale that will be encountered have weathered to common excavation. The limestone zone in this shale formation is rock excavatio

The Middleburg limestone is rock excavation.

The Keener shale member that will be encountered has weathered to common excavation.

The limestone units of the Kiss limestone member are rock excavation. The shale unit of this member is common excavation when weathered. It is weathered at this location unless it is overlain by the upper Kiss limestone units.

The stearns shale that will be encountered has weathered to common excavation.

2. Cut Section from Station 107/50 to Station 110/50.

Backslopes

The lower 3 to 4 feet of the Cottonwood limestone is exposed at the surface between the above stations. The Eskridge shale, which underlies the Cottonwood limestone, is weathered to a depth of 3 to 4 feet under the remnants of the overlying limestone.

The Cottonwood limestone, at this location, is weathered and contains numerous horizontal and vertical joints. Backslopes of $\frac{1}{4}$:1 or flatter will stand satisfactorily.

Backslopes of 1:1 or flatter are suggested for the weathered Eskridge shale. Backslopes of $\frac{1}{2}$:1 or flatter will stand satisfactorily for the Eskridge shale that is rock excavation.

Rock Excavation

The Cottonwood limestone is rock excavation. The Eskridge shale has weathered to common excavation to a depth of three feet under the Cottonwood limestone at station 109/00, at centerline, and to a depth of four feet at the outcropping edge of the overlying limestone.

Overbreakage

The Cottonwood limestone at this location is weathered and has numerous horizontal and vertical joints. However, several of the limestone blocks will be of large size, therefore, a small amount of overbreakage, depending upon the grade line, may be encountered.

3. Cut Section from Station 113/00 to 125/00

Backslopes

[illegible] limestone, Stearns shale, Cottonwood limestone and

a small amount of the Eskridge shale will be encountered at this location. These bedrock units are overlain by one foot or less of mantle which is predominantly a silty clay. The lower portion of the weathered Stearns shale will be encountered in the extreme upper portion of the backslopes. The Morrill limestone consists of a thin, brown, impure, cellular limestone at this location and has weathered to common excavation. The Florena shale is weathered and has a moisture content that varies from being very moist to damp. All three of these bedrock units have had ground water moving through them from left to right across centerline. This ground water movement will have a tendency to cause the left backslope to become unstable unless it is laid back on a fairly flat slope.

Backslopes of 2:1 or flatter are suggested for the thin mantle.

A slope of $1\frac{1}{2}$:1 for the left backslope and 1:1 for the right backslope is suggested for the Stearns shale, Morrill limestone and the Florena shale through this location.

The Cottonwood limestone will stand on a $\frac{1}{4}$:1 slope satisfactorily.

Backslopes of $\frac{1}{2}$:1 or flatter for rock excavation and 1:1 or flatter for common excavation are suggested for the Eskridge shale.

Rock Excavation

The Stearns shale, the thin, impure Morrill limestone and the Florena shale have been subjected to ground water movement at this location; therefore, they have been weathered to common excavation.

The Cottonwood limestone is rock excavation.

The Eskridge shale has weathered to common excavation to a depth of 13.0 feet at the edge of the Cottonwood limestone outcrop at station 114/81, centerline, 12.0 feet at station 121/68, centerline, and 14.0 feet at station 124/19, centerline. This depth of weathering is due to past ground water movement at the base of the Cottonwood limestone and through the Eskridge shale. The depth of weathering of the shale will decrease from 13.0 feet at station 114/81 to 0.0 at station 116/30 and from 12.0 feet at station 121/68 to 0.0 at station 119/30.

Overburden

A small amount of [illegible] will be encountered in the left ditch and [illegible] through this location, depending upon the grade line.

Hydrology

There is evidence that there has been a strong flow of ground water from left to right across this location. The Burrill limestone and Florena shale have had ground water movement within them. The Florena shale has a zone that lies between an elevation of 1154.2 and 1152.2 at station 118/00 that was very moist and soft at the time of this investigation.

It is probable that the base of the Cottonwood limestone will be carrying ground water during normal annual rainfall periods.

Subdrainage should be considered if the grade line crosses over the zone mentioned in the Florena shale if the left ditch does not cut below it one foot.

The base of the Cottonwood limestone should be drained if it is cut by the grade line.

At 61 feet right of station 121/00 is the edge of a small pond. The elevation of the water level in this pond is 1134.0. This water level appears to be rather stable. The pond is being used for watering cattle. It appears that this pond is spring fed, although there is no visible evidence to support this. There is evidence, however, that there has been ground water moving through this area from left to right across centerline. Therefore, since the water level has been stable through the past dry season and the drainage into the pond is very small, it is assumed that the pond has ground water moving into it.

4. Cut Section from Station 129/50 to Station 135/00

Backslopes

The Eskridge shale that is overlain by a silty clay mantle will be encountered at this location. The mantle thickness varies from 1.5 to the left of centerline to 12 feet at station 130/00, centerline.

Backslopes of 2:1 or flatter are suggested for the mantle.

Backslopes of 1:1 or flatter for common excavation and ½:1 or flatter for rock excavation are suggested for the Eskridge shale formation.

Rock Excavation

The Eskridge shale is common excavation where it is weathered. It is weathered to an average depth of 8.4 feet at the cross-section of station 132/00.

5. Cut Section from Station 138/00 to Station 153/75

Backslopes

The Eskridge shale, Neva limestone and possibly a small amount of Salem Point shale will be encountered through this location; however, the majority of the material will consist of a loess-like silty clay that is 25 feet thick at station 148/00. This thick mantle deposit lies in a buried valley that extends from station 142/00 to station 152/00. The Eskridge shale will be encountered on a side hill between stations 138/00 and 142/00. The Neva limestone and Salem Point shale may be encountered in the vicinity of station 153/00, depending upon the grade line.

Backslopes of 2:1 or flatter are suggested for the silty clay mantle. Care should be taken to divert any surface drainage that would flow over the mantle backslopes as it is susceptible to erosion.

Backslopes of 1:1 or flatter for common excavation and $\frac{1}{2}$:1 or flatter for rock excavation are suggested for the Eskridge shale formation.

Backslopes of $\frac{1}{4}$:1 are suggested for the Neva limestone member. The shale units in this limestone member are either very limy and resistant or so thin that they will cause no concern as far as backslope stability.

Backslopes of 1:1 or flatter for common excavation and $\frac{1}{2}$:1 or flatter for rock excavation are suggested for the Salem Point shale.

Rock Excavation

The Eskridge shale formation has weathered to common excavation to a depth of from 8 to 10 feet through this location.

The limestone units of the Neva limestone member are rock excavation. The upper shale zone of the Neva limestone is quite limy and resistant to weathering. It has weathered to common excavation to a depth of 1 foot in the vicinity of station 133/00.

The Salem Point shale is weathered to common excavation where it is overlain by four or more feet of Neva limestone.

6. Cut Section from Station 161/50 to Station 187/00

Backslopes

The Cottonwood limestone, Eskridge shale and Neva limestone will be encountered in the right backslope through this side hill location. The bedrock is covered with a thin mantle that consists of silty clay and limestone fragments and blocks.

Backslopes of 2:1 or flatter are suggested for the mantle.

The Cottonwood limestone will stand on a $\frac{1}{4}$:1 slope satisfactorily.

Backslopes of 1:1 or flatter for common excavation and $\frac{1}{2}$:1 or flatter for rock excavation are suggested for the Eskridge shale formation.

Backslopes of $\frac{1}{4}$:1 or flatter will stand satisfactorily for the Neva limestone member. The shale units in this limestone member are either very limy and resistant or so thin that they will be stable on the $\frac{1}{4}$:1 slope.

Rock Excavation

The Cottonwood limestone is rock excavation.

The Eskridge shale has weathered to common excavation to a depth of 7 to 8 feet when it is not overlain by the Cottonwood limestone.

The limestone units of the Neva limestone member are rock excavation. The upper limy shale zone is common excavation when weathered. It is weathered to a depth of 0.5 feet at this location.

Hydrology

A spring approximately 340 feet right of station 173/00 is piped to a stock tank. The spring is practically dried up at this time. The source of ground water is from the Morrill limestone.

7. Cut Section from Station 189/00 to Station 204/00

Backslopes

The Morrill limestone, Florena shale, Cottonwood limestone and Eskridge shale will be encountered in the right backslope through this location. The thin mantle deposit that will be encountered consists of silty clay and limestone fragments.

A slope of 2:1 or flatter is suggested for the thin mantle.
The Morrill limestone will stand on a $\frac{1}{4}$:1 slope satisfactorily.

A slope of 1:1 or flatter for common excavation and ½:1 or flatter for rock excavation is suggested for the Fairview shale.

The Cottonwood limestone will stand on a ½:1 slope satisfactorily.

A slope of 1:1 or flatter for common excavation and a ½:1 or flatter for rock excavation is suggested for the Fairridge shale formation.

Rock Excavation

The Morrill limestone is rock excavation.

The Florena shale is common excavation where it is weathered. This shale is weathered along this side hill location unless it is overlain by the Morrill limestone.

The Cottonwood limestone is rock excavation.

The Eskridge shale is common excavation where it is weathered. It is weathered to a depth of approximately 7 feet through this location where it is not overlain by the Cottonwood limestone.

8. Cut Sections from Station 210/00 to Station 220/00 and From Station 223/00 to Station 240/00.

Backslopes

The Easly Creek shale, Middleburg limestone, Hooser shale, Wise limestone, Stearns shale and Morrill limestone will be encountered through these two side hill locations. These formations and members are overlain by a thin mantle that consists of limestone fragments and silty clay. There will be little if any backslope to the left of centerline through this area.

Backslopes of 2:1 or flatter are suggested for the thin mantle.

Backslopes of 1½:1 or flatter for common excavation and 1:1 or flatter for rock excavation are suggested for the Easly Creek shale. These slopes are suggested because the Crouse limestone, which overlies this shale, has some ground water moving along its base. Therefore, there is a possibility that this shale will slip out on a steep slope.

The Middleburg limestone will stand on a ½:1 slope satisfactorily. The thin shale unit of this member will stand on a ½:1 slope for both rock and common excavation.

Backslopes of 1:1 or flatter for common excavation and ½:1 for rock excavation are suggested for the Stearns shale formation.

The Morrill limestone will stand on a vertical slope satisfactorily.

Rock Excavation

The Easly Creek shale is common excavation when it is weathered. It has been weathered rather extensively at these two locations. The upper 8.6 feet of this formation is weathered unless it is overlain by the 4.1 foot thick limestone of the lower Crouse formation. At this point the rock and common contact projects up until the complete Crouse limestone section overlies it. The lower 14.9 feet of the Easly Creek shale has weathered to the depth of 5.1 feet to the right of station 215/00. This depth of weathering is 8 feet between station 233/00 and station 236/00. The limestone units in the Easly Creek shale are rock excavation.

The Middleburg limestone is rock excavation.

The Hooser shale is weathered to common excavation through these locations when it is not overlain by a full thickness of Middleburg limestone.

The limestone units of the Kiss limestone are rock excavation. The thin shale unit of this member is weathered to common excavation unless it is overlain by four or more feet of bedrock.

The Stearns shale is common excavation when it is weathered. It has weathered to a depth of approximately 7 feet through these two locations when it is not overlain by the Kiss limestone.

The Morrill limestone is rock excavation.

Hydrology

At station 233/89, 90 feet right there is a 10 feet square seep area that has a rank growth of vegetation. This seepage is coming from the base of the Crouse limestone. This seepage will not affect the roadway, however, it may cause the underlying Easly Creek shale to slide out if it is put on a steep slope.

9. Cut Section from Station 264/00 to Station 276/00

Backslopes

The Crouse limestone, Easly Creek shale, Middleburg limestone and Hooser shale

ness from 0 to 6.0 feet and consists of silty clay with some limestone fragments and blocks.

Backslopes of 2:1 are suggested for the mantle.

The Crouse limestone will be encountered in the left backslope between station 274/00 and station 276/00. The shaly limestone of the upper Crouse limestone formation will stand on a $\frac{1}{2}$:1 or flatter slope satisfactorily. The lower limestone zone is blocky and somewhat massive. It will stand on a vertical slope.

Backslopes of $1\frac{1}{2}$:1 or flatter are suggested for the Brady Creek shale that is common excavation as it has a moisture content that varies from moist to wet. A backslope of $\frac{1}{2}$:1 or flatter will stand satisfactorily for the shale that is classified as rock excavation. The limestone zone in this shale formation will stand on a $\frac{1}{4}$:1 slope.

The Middleburg limestone member will stand on a $\frac{1}{4}$:1 slope or flatter.

Backslopes of 1:1 or flatter for common excavation and $\frac{1}{2}$:1 or flatter for rock excavation are suggested for the Hooser shale member.

Rock Excavation

The upper shaly limestone zone of the Crouse limestone formation has weathered to common excavation to a depth of 1.5 feet at this location. The lower limestone zone is rock excavation.

The Brady Creek shale is common excavation when it is weathered. This shale formation has weathered rather deeply through this location due to ground water movements at the base of the Crouse limestone. The limestone zone in this shale formation is rock excavation. The average depth of weathering of the shale is approximately 13.0 feet when it is not overlain by the Crouse limestone. This depth of weathering decreases to 0.0 when the shale is overlain by the complete section of the Crouse limestone.

The limestone zones of the Middleburg limestone are rock excavation. The thin shale is weathered to common excavation unless it is overlain by the upper Middleburg limestone.

The Hooser shale member is common excavation where weathered. Its depth of weathering varies from 8.0 feet on the side slopes to 1.5 feet between station

260/00 and station 262/00, where it is overlain by weathered limestone fragments and blocks of the Middleburg limestone.

Hydrology

The Ewly Creek shale was found to have a rather high moisture content through this location. At station 269/00, 74 feet left, it is moist and soft from an elevation 1220.5 to 1213.8. At station 272/50, centerline, it is very moist and soft from an elevation of 1221.8 to 1215.1. At station 277/23, centerline, it is very moist and soft at an elevation of 1220.5 and saturated at 1212.5. It is thought that this moisture content originated from the base of the Crouse limestone and has moved down through the weathered shale. The Crouse limestone is not carrying water at this time due to the prevailing dry condition.

The moisture condition described above is not a concentrated ground water movement. The left ditch, which will act as a surface interceptor, should give protection from any addition to the present moisture content that will directly affect the roadway. The very moist shale that is encountered during construction may require drying before it is used as subgrade material. It has a tendency to hold its moisture for a considerable length of time, and since the shale is soft and badly weathered, a failure may develop.

10. Cut Sections from Station 283/00 to Station 320/00

Backslopes

Centerline cuts across several topographic noses along this location. The Blue Rapids shale, Crouse limestone and a small amount of Ewly Creek shale will be encountered. The mantle varies in thickness from 1.0 to 9.0 feet and consists of silty clay with varying amounts of limestone fragments and blocks.

Backslopes of 2:1 or flatter are suggested for the mantle.

Backslopes of 1:1 or flatter for common excavation and ½:1 or flatter for rock excavation are suggested for the Blue Rapids shale.

Backslopes of ½:1 are suggested for the upper shaly limestone of the Crouse limestone. The lower limestone unit of this formation will stand on a vertical slope.

The small amount of Ewly Creek shale that will be encountered is weathered to common excavation. Backslopes of 1:1 or flatter are suggested for the shale

of this formation. The limestone unit in the Easly Creek will stand on a ¼:1 slope satisfactorily.

Rock Excavation

The Blue Rapids shale is common excavation when weathered. Its depth of weathering varies from 2.2 to 4.5 feet through this location.

The Crouse limestone is rock excavation except where the upper shaly limestone is weathered. Its depth of weathering varies from 0.0 to 2.5 feet. However, the 2.5 depth of weathering is an exceptional case. Ordinarily, the weathering depth will be from 0.0 to 0.5 foot.

The Easly Creek shale that will be encountered in the vicinity of station 285/00 has weathered to common excavation. The limestone unit in this formation is rock excavation.

Hydrology

There is very little evidence that the Crouse limestone is carrying ground water in the vicinity of station 284/00. However, it is a good possibility that this limestone formation is a potential ground water carrier at this location and that it will have ground water moving at its base during normal rainfall periods. It is suggested that this location be checked during construction to determine if subdrainage is desirable if the base of the Crouse limestone formation is cut by the grade line.

Between stations 315/00 and station 319/00, the upper portion of the Crouse limestone and the lower portion of the Blue Rapids shale will be encountered. It is possible that there has been ground water moving along the top of the Crouse limestone at this location. The Blue Rapids shale at centerline was dry, however, at station 318/00, 60 feet left, the shale was wet directly above the limestone. This location should be checked during construction to see if subdrainage is desirable. It is possible, depending upon the grade line, that the left ditch would intercept any ground water moving along the top of the limestone.

11. Cut Section from Station 324/00 to Station 331/50

Backslopes

The Blue Rapids shale that is overlain by a silty clay mantle will be encountered at this location.

Backslopes of 2:1 or flatter are suggested for the mantle.

Backslopes of 1:1 or flatter for common excavation and $\frac{1}{2}$:1 or flatter for rock excavation are suggested for the Blue Rapids shale.

Rock Excavation

The Blue Rapids shale is common excavation when it is weathered. It has weathered to a depth of 6.5 feet through this location.