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# A study of drumlins in the Tobacco Plains/Stillwater Valley and Seeley/Swan Valley in Montana

Eric D. Zimmerman
*The University of Montana*

# A STUDY OF DRUMLINS IN THE TOBACCO PLAINS/STILLWATER VALLEY AND SEELEY/SWAN VALLEY IN MONTANA

by

**Eric D. Zimmerman**

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**Approved by:**

John J Donahue

**Chairperson**

**Dean, Graduate School**

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A Study of Drumlins in the Tobacco Plains/Stillwater Valley and Seeley/Swan Valley in Montana.

Director: John J. Donahue, PhD

The purpose of this study was to examine the morphometry of valley drumlins in two study areas in Montana, compare their morphometries to identify common and dissimilar characteristics, compare two different drumlin delineation definitions, suggest possible explanations for significant morphometric differences between the two fields, identify which morphometrics best describe valley drumlins, and make broad comparisons between morphometries of the Montana valley drumlins and drumlins reported in the literature. Morphometric measurements were taken from 1:24,000 scale 7½ minute topographic maps. Comparisons were made using a combination of descriptive statistics, t-tests, and maps. Principal component analysis was used to determine which morphometrics best describe each field. Nearest-neighbor analysis and drumlin density was used to examine drumlin distribution.

The two drumlin fields are located in northwestern Montana. The first study area is in the Seeley/Swan Valley, east of the Mission Mountain Range and the second is in the Tobacco Plains/Stillwater Valley near the town of Eureka. These two drumlin study areas are located in confined valley environments opposed to the usual unconfined plains environments.

The results of the research showed that there were significant differences between the two Montana drumlin fields. These significant differences were most likely due to glaciological factors of each study area opposed to geological factors. In general, the two Montana fields were fairly comparable to drumlin fields reported in the literature; however, the drumlins in the Montana fields were narrower than any other reported in the literature. This may have been due to the confined nature of valley drumlins; as opposed to plains drumlins.

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### Drumlin Metric Abbreviations

The drumlin metric abbreviations for this thesis are as follows:

Drumlin Length – *DL*

Drumlin Width – *DW*

Drumlin Height – *DH*

Drumlin Area – $DA_b$

Drumlin Long Link Length - $DL_{ll}$

Drumlin Short Link Length - $DL_{sl}$

Drumlin Orientation – *DO*

Drumlin Lateral Slope – $DS_l$

Drumlin Long Link Slope – $DS_{ll}$

Drumlin Short Link Slope – $DS_{sl}$

Drumlin Compactness Ratio – *DCR*

Drumlin K Value – *K*

Drumlin Length/Width Ratio – *L/W*

Drumlin Length/Height Ratio –*L/H*

Drumlin Width/Height Ratio – *W/H*

Drumlin Lee/Stoss Slope Ratio – *L/S*

Drumlin Volume – *DV*

### Drumlin Field Metric Abbreviations

The drumlin field metric abbreviations for this thesis are as follows:

Average Field Length (*FL*)

Average Field Width (*FW*)

Field Compactness Ratio (*FCR*)

Percent Area Drumlins ($F_dP$)

Density per Sq. Kilometer ($F_dD$)

Field Area (*FA*)

Number of Drumlins ($F_dN$)

Number of Drumlin Twins ($F_dT$)

# CHAPTER 1

# INTRODUCTION

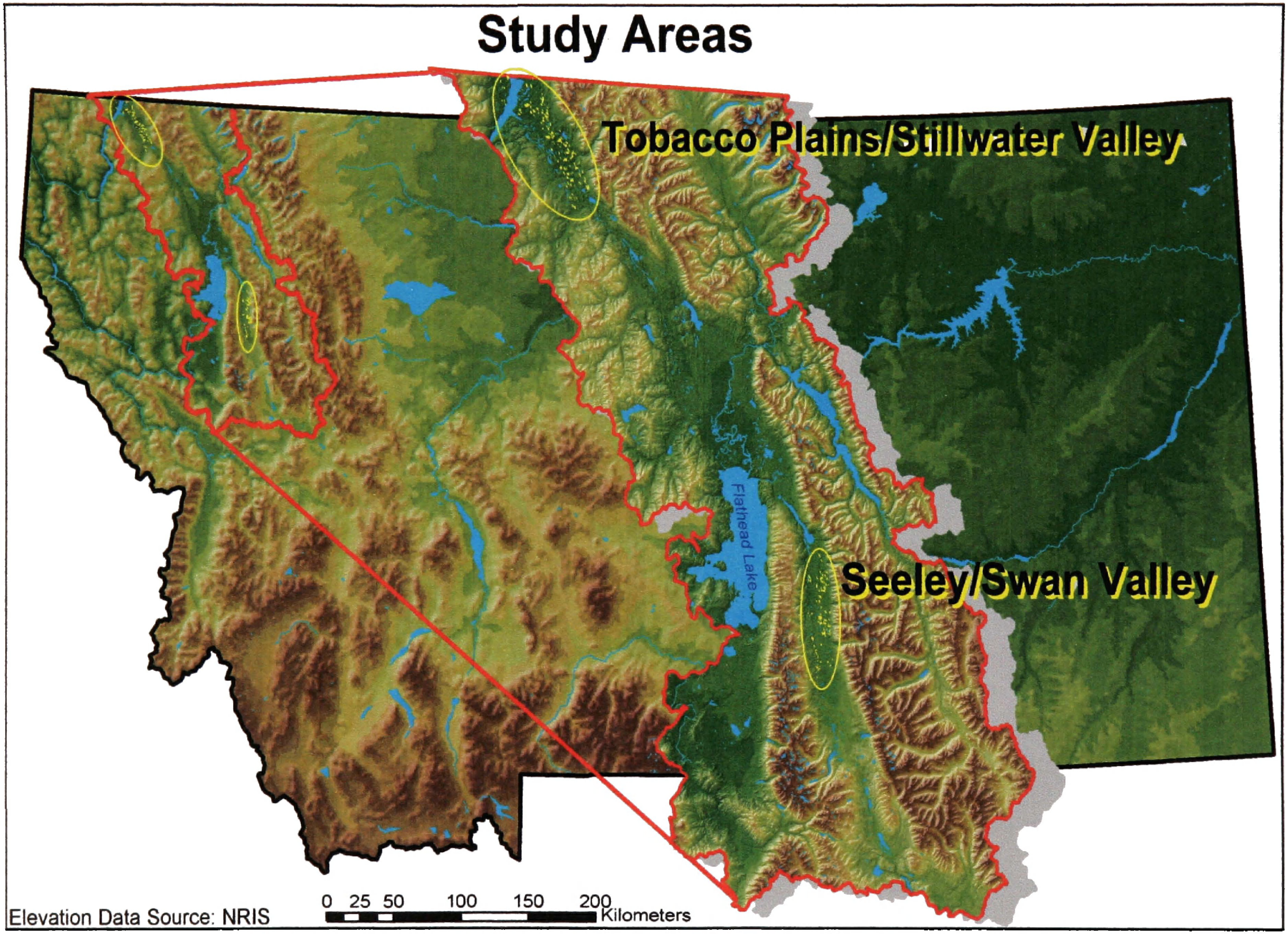
The term 'drumlin' is derived from the Gaelic word druim, meaning mound or rounded hill (Embleton and King 1969, 322). The first person to bring the term 'drumlin' into scientific literature was Maxwell Close in 1867 (Menzies 1984, xi). Drumlins are low-lying elongated hills formed by glacial action and are typically, if not entirely, composed of till. Their unique shape displays a steep stoss end and a gentle lee end. They often have a semi-elliptical shape similar to the bowl of an inverted spoon or the upper half of an egg viewed in longitudinal section (Reed, Galvin, and Miller 1962, 2001). The typical longitudinal drumlin profile resembles an airplane wing cross-section. Drumlins were formed under glaciers, but whether by erosion, deposition, or in combination is in dispute. Not all glaciers have drumlins formed beneath them, leading to the conclusion that a specific combination of controls is probably needed to form drumlins. Drumlins range in height from about five to fifty meters and in length from a hundred to more than a thousand meters. They tend to be aligned parallel to the direction of former ice flow. They are easily recognized in air photos and topographic maps, and large drumlins can be detected on digital elevation models (DEMs). Notable drumlin fields occur in Ireland, Scotland, Switzerland, Germany, Canada, Alaska, and the

northern United States. They are particularly prominent in Upstate New York and around the Great Lakes.

**Problem Statement**

Geomorphologists have generated a great deal of morphometric data (quantitative characterization of geometrical elements and derivatives) and information about drumlins in regions of slight relief formerly covered by sub-continental size glaciers. Such drumlins are called here plains drumlins. In contrast, geomorphologists have contributed little to the description and mapping of drumlins generated on valley floors in mountainous settings. In fact, Muller (1974, 188) said "drumlins are characteristic of, but not entirely restricted to, areas of ice sheet (unconfined) as opposed to valley (confined) glaciation." In part, the shortage of data is owing to a scarcity of these drumlins, called here valley drumlins. With the exception of a study made in Europe (van der Meer and van Tatenhove 1992) and one in British Columbia (Armstrong and Tipper 1948), the morphology of valley drumlins remains largely unexamined, especially in the United States. In consequence, valley drumlins have not been quantitatively assessed. The gathering of such morphometric data could lead to comparisons of drumlin shapes between drumlins developed in different glacial settings. We do not know whether valley drumlin morphology differs significantly from one drumlin to another within a swarm (field) or whether general drumlin morphology differs significantly between swarms. Lacking morphological data, no specific comparisons can be made between valley drumlins and plains drumlins.

Figure 1. Study Area Map



**Study Area**

The two drumlin fields in this study are located in northwestern Montana (Figure 1). The Seeley/Swan Valley drumlin field lies between the Mission Range bordering the west side and the Swan Range bordering the east. The Seeley/Swan Valley drumlins were formed beneath the Swan Valley Glacier, most likely during the Wisconsin age (10,000 to 70,000 years ago) (Witkind 1978, 427-428; Witkind and Weber 1982). The Swan Valley glacier had a northwesterly flow and ended up merging with the Flathead Lobe of the Cordilleran ice sheet near Big Fork (Johns 1970, 8; Witkind and Weber 1982). The surficial geology of the Seeley/Swan Valley is composed of relatively unmodified glacial till which was shaped into drumlins (Appendix A) (Witkind 1978, 427-428; Witkind and Weber 1982).

The Tobacco Plains/Stillwater Valley drumlin field is located near the Canadian border and lies between the Purcell Mountains to the west and the Whitefish Range to the east. The Tobacco Plains/Stillwater Valley drumlins were formed beneath the Flathead Lobe of the Cordilleran Ice sheet most likely during the Wisconsin age (10,000 to 70,000 years ago) (Johns 1970, 7; Silkwood 1998). The surficial geology of the Tobacco Plains/Stillwater Valley is predominantly glacial till overlain by drumlins (Appendix A).

**Hypotheses**

$H_1$: Significant differences in drumlin morphometry exist between the two drumlin fields of Montana.

$H_2$: Significant morphometric differences exist between different drumlin delineation criteria/definitions applied to the two Montana drumlin fields.

Two definitions of drumlin were used in the study owing to contour interval differences between source topographic maps. These two definitions are addressed in the methods section of this thesis p.13.

**Objectives**

Valley drumlins characterize two areas of Montana. The valley drumlin fields appear on the Tobacco Plains/Stillwater Valley and the Seeley/Swan Valley of western Montana (Figure 1). These drumlins and drumlin fields were quantitatively described in detail. In this study I shall (1) examine their morphometry, (2) compare their morphometries to identify common and dissimilar characteristics, (3) examine spatial distributions and relationships between drumlins, (4) suggest possible explanations for significant morphometric differences between drumlins in the two fields, (5) identify which morphometrics best describe valley drumlins, and (6) make comparisons between morphometries of the Montana valley drumlins and plains drumlins reported in the literature. No attempt will be made to identify processes of drumlin genesis.

# CHAPTER 2

# LITERATURE REVIEW

Much literature has been published on drumlins, some dating back to the early 1800s. In fact, Menzies (1984) published a book containing more than 1000 references to drumlins. This literature review consists of two parts. The first part involves drumlin morphometry and the second drumlin genesis.

## Drumlin Morphometry Literature

Much published research has been devoted to the measurement of drumlin geometry hoping to shed light on drumlin genesis. The expectation has been that linkages exist between elements of drumlin shape and sub-ice conditions during drumlin formation. In addition, morphometrical research has been devoted to generating more precise geographical descriptions of drumlins and drumlin fields (regions) (Chorley 1959; Reed, Galvin, and Miller 1962; Heidenreich 1964; Embleton and King 1969; Dardis, Doornkamp and King 1971; Williams 1972; Hill 1973; Muller 1974; Crozier 1975; Jauhiainen 1975; Rose and Letzer 1975; Trenhaile 1971, 1975; Mills 1980; Gardiner 1983; McCabe, and Mitchell 1984; Harry and Trenhaile 1987; Piotrowski and Smalley 1987; Riley 1987; Coude 1989; Haavisto-Hyvarinen, Kielosto, and Niemela 1989; Francek and Blish 1991; Smalley and Warburton 1994; Wysota 1994; Knight 1997;).

Morphometric analysis generates quantitative data that may be used to calculate mean dimensions, ranges, ratios, and the like (King 1974, 147). Metric values provide generally reliable data for inferences about genesis or for making geographical comparisons between drumlins or drumlin fields.

**Common Metrics** – Common drumlin metrics include length, width, height, and length/width ratio (elongation). Drumlin *length* is measured along the drumlin long axis, which may not necessarily be drawn as a straight line (Trenhaile 1975, 301; Mills 1980, 2240). Drumlin *width* is measured at right angles to the long axis at the widest part of the drumlin (Heidenreich 1964, 102; Trenhaile 1975, 301; Mills 1980, 2240). Drumlin *height* and crest elevations are measured by reference to a summit benchmark elevation or by adding one half of a contour interval above the highest closed contour where benchmarks are lacking (Miller 1972, 419; Francek and Blish 1991, 110). Additionally, Clapperton (1989, 391) found that the highest point on most plains drumlins in Chile was often within 200-300 m of the stoss end.

The most common morphometric ratio is the *elongation* or *length/width* (l/w) ratio. Greater elongation indicates more streamlining by glacial ice, possibly due to high ice velocities (Charlesworth 1957, 394; Embleton and King 1969, 324; Crozier 1975, 185). The inverse of the l/w ratio calculation, the *w/l* ratio, is sometimes used instead as a shape indicator (Smalley and Unwin 1968, 382; Jauhiainen 1975, 224). One advantage of the w/l ratio over the l/w ratio is that its theoretical values range from 0-1, whereas the l/w values theoretically range from 0 to ∞.

**Less Common Metrics** – Drumlin area, stoss slope, lee slope and orientation are somewhat less typical metrics, while drumlin length/height, width/height, lee slope/stoss slope ratios, and lemniscate loops are seldom reported.

One metric relating to streamlining is the *lemniscate loop*, applied by Chorley (1959), which has a more complex formula than the simple l/w calculation. Chorley demonstrated that the base contour of drumlins could be characterized by the lemniscate loop equation (1),

$$p = L \cos k\theta$$

where $L$ is the length of the long axis and $k$ is a dimensionless number expressing the elongation of the lemniscate loop, such that when $k$ equals unity the form is circular, and that $k$ increases with the elongation of the lemniscate loop. To calculate the value of $k$, the equation (2),

$$k = L^2\pi / 4A$$

is used where $A$ is the area enclosed by the loop or base contour. To obtain the best-fit lemniscate loop approximation of drumlin shape, only the values of $L$ and $A$ are used. These are substituted into equation (2) to get the *k value*, which is then substituted back into equation (1) (Chorley 1959, 341). Trenhaile (1975, 305) and Doornkamp and King (1971, 300) have both reported that $k$ values correlate highly to the length/width ratio. Trenhaile (1975, 305) reported correlation coefficients 0.99 and 0.94 and Doornkamp and King (1971, 300) reported a correlation coefficient of 0.98. Oftentimes since the $k$ value correlates so closely with the l/w ratio, the latter alone is used in morphometric analysis, thereby eliminating the additional calculation of the lemniscate loop.

Compass *orientation* of drumlin long axes has been used to determine ice flow directions and to determine whether ice-flow through a field was straight a or had a curved flow direction (Trenhaile 1975, 302-303). Most commonly, the orientation of the drumlins are shown as frequency distributions, typically broken down into intervals of ten degrees (Vernon 1966, 406; Williams 1972, 780; Jauhiainen 1975, 225).

**Drumlin Distribution** - Drumlin density and distribution pattern types have been examined by some researchers. Drumlin density (the number of drumlins per unit area) has been used to determine the degree to which drumlins are packed within a field (Vernon 1966, 404-405; Doornkamp and King 1971, 294-298; Hill 1973, 231; Jauhiainen 1975, 226; Trenhaile 1975, 306; Coude 1989, 325; Francek and Blish 1991, 109-110). Distribution type is obtained by nearest-neighbor analysis, which is based on the linear distance from the highest point of one drumlin to the highest point of its nearest neighbor in the drumlin field (Jauhiainen 1975, 226). The analysis indicates whether drumlin distribution in a field is random or clustered (Vernon 1966, 404; Smalley and Unwin 1968, 385-387; Trenhaile 1971, 116-117; Hill 1973, 227-228; Jauhiainen 1975, 226-227; Harry and Trenhaile 1987, 166).

**Drumlin Field Morphometry** - Major morphometric differences between drumlin fields may indicate that different regional sub-ice conditions prevailed during drumlin formation. By examining drumlin morphometry of similar and different drumlin fields, insights into sub-ice conditions during genesis can be obtained (Chorley 1959, 340; Francek and Blish 1991, 110).

**Drumlin Genesis Literature**

Despite many drumlin studies, no single explanation of drumlin genesis has received universal acceptance. There are currently two seemingly contradictory hypotheses about drumlin formation.

**Erosional Hypothesis** - The first hypothesis invokes the process of erosion (Tarr 1894; Gravenor 1953; Charlesworth 1957; Flint 1957; Harry and Trenhaile 1987; Shaw and Sharpe 1987; Habbe 1989; Shaw, Kvill, and Rains 1989; Boyce and Eyles 1991; Fisher and Spooner 1994). The most common erosion hypothesis envisions two-stages. The first stage involves the deposition of a blanket of till by an earlier ice advance. The second involves subsequent molding and minor redistribution of the till surface (Embleton and King 1969, 339). Another hypothesis relates to glaciofluvial erosion. In this hypothesis subglacial meltwater is thought to be capable of eroding till or sediment at a glacier's sole, leaving disconnected medial ridges as drumlins (Shaw and Sharpe 1987, 2322; Fisher and Spooner 1994, 285).

**Depositional Hypothesis** - The second formation hypothesis invokes deposition (Davis 1884; Gravenor 1953; Charlesworth 1957; Vernon 1966; Hill 1971; Shaw 1983; Shaw and Kvill 1984; Piotrowski and Smalley 1987; Sharpe 1987; Haavisto-Hyvarinen, Kielosto, and Niemela 1989; van der Meer and van Tatenhove 1992; Nenonen 1994). The most agreed-upon theory relates to progressive lodgment of drift around a rock knob, boulder obstacle, or block of frozen till or debris (Gravenor 1953, 675; Charlesworth 1957, 397; Vernon 1966, 407; Nenonen 1994, 365). Another notion involves glaciofluvial deposition proposed by Shaw (1983), Shaw and Kvill (1984), and Sharpe (1987). This hypothesis proposes that subglacial meltwater first erodes cavities into the

basal ice which are then filled by deposits during waning ice meltwater flow (Shaw, Kvill, and Rains 1989, 177-178).

**Combination Hypothesis** - Some researchers believe that both erosion and deposition are valid hypotheses with erosion acting under one set of circumstances and deposition acting under another (Fairchild 1905; Charlesworth 1957; Flint 1957; Gravenor 1957; Embleton and King 1969; De Jong, Rappol, and Rupke 1982; Dardis, McCabe, and Mitchell 1984; Boulton 1987; Kruger 1987; McCabe and Dardis 1989; Stea and Brown 1989; Jones 1996; Knight 1997). Indeed, a few researchers believe that drumlin generation necessitates both erosion and deposition acting in concert. "Drumlins are an expression of the equilibrium between the erosive action of ice and the opposing forces of the solidity and cohesion of the material; the "plastering on" and "rubbing down" processes took place at the same time or in rhythmic alternation" and "the two views of erosion and accretion are reconcilable; they emphasise different aspects of one process" (Charlesworth 1957, 399).

# CHAPTER 3

# METHODOLOGY AND PROCEDURES

## Data Sources and Acquisition Methods

**Existing Data** – Glacial history and underlying geology for the two study areas were derived from a combination of reports, paper maps, and digital data. Digital geologic data for the two study areas were acquired from the U.S. Geological Survey (USGS). The USGS derived the digital data from 1:250,000 scale paper geological maps. The paper source map for the Seeley/Swan Valley was the Choteau 1 x 2 degree quadrangle (Mudge et al. 1982), and the paper source map for the Tobacco Plains/Stillwater Valley was the Kalispell 1 x 2 Degree quadrangle (Harrison, Cressman, and Whipple 1992). Two additional published maps showing the geology of the Seeley/Swan Valley were used (Witkind 1995; Witkind and Weber 1982) as well as a report by Witkind (1978) which dealt with the the glacial history of the Seeley/Swan Valley. A report by Johns (1970) dealt with the geology and glacial history of the Tobacco Plains/Stillwater Valley. I also made use of a U.S. Forest Service (USFS) map (Silkwood 1998), which illustrated the areas in western Montana that were inundated by glacial ice and pro-glacial lakes.

**Drumlin Delineation** – I manually delineated drumlins identified on USGS 7 ½ minute topographic maps. All maps complied with National Map Accuracy Standards

(Appendix D). The Seeley/Swan Valley drumlins were traced on the Swan Lake, Cilly Creek, Salmon Prairie, Swan Peak, and Peck Lake quadrangles. The Tobacco Plains/Stillwater Valley drumlins were traced on the Rexford, Eureka North, Eureka South, Ksanka Peak, Fortine, Mount Marston, Edna Mountan, and Stryker quadrangles (Appendix B provides a quadrangle index map).

The drumlins were traced according to the two operational definitions that follow. Definition #1: A drumlin is an elliptical hill expressed on 7 ½ minute contour maps by nearly parallel nested elliptical contours being generally symmetrical about a longitudinal axis and expressed by at least two contour lines on 40-foot contour interval maps and three contour lines on 20-foot contour interval maps. This compound definition was applied because some study area maps had 20-foot contour intervals and others had 40-foot contour intervals. The smaller contour interval systematically makes the delineation of smaller drumlins possible. In consequence, small drumlins would be inadequately represented on larger interval maps.

Definition #2: A drumlin is an elliptical hill expressed on 7 ½ minute contour maps by nearly parallel nested elliptical contours being generally symmetrical about a longitudinal axis and expressed by at least two contour lines on both 40-foot contour interval maps and 20-foot contour interval maps. This second definition was used in order to conduct a comparison with drumlins reported in the literature, all of which were based on 20-foot contour interval sources. Additionally, the second definition was used to determine whether there were significant differences between the two drumlin delineation definitions. In the Seeley/Swan Valley, two of the five quadrangles made use of 20-foot contour intervals (Cilly Creek and Salmon Prairie). In the Tobacco/Stillwater

Valley three of the eight quadrangles made use of 20-foot contour intervals (Rexford, Eureka North, and Fortine). However, those three quadrangles for the Tobacco Plains/Stillwater Valley encompassed most of the valley and contained 88% of the drumlins delineated using the second definition.

Some researchers define the drumlin base as the lowest closed elliptical contour line. However, this can cause underestimation of the size of some drumlins. One case in point is where two drumlins are fused or connected. In this situation the lowest elliptical contour presents an underestimation of drumlin size. To avoid this type of underestimation, I used the method described by Mills (1980, 2237), which took a lower contour line that was not elliptical and projected a line through the pass or gap perpendicular to the saddle to separate the fused drumlins (Figure 2). The criterion used to determine which non-elliptical contour to use as the two new base contours was the non-elliptical contour where the projected line length was not greater than 25% of the circumference length of the new base contour lines (Figure 2).

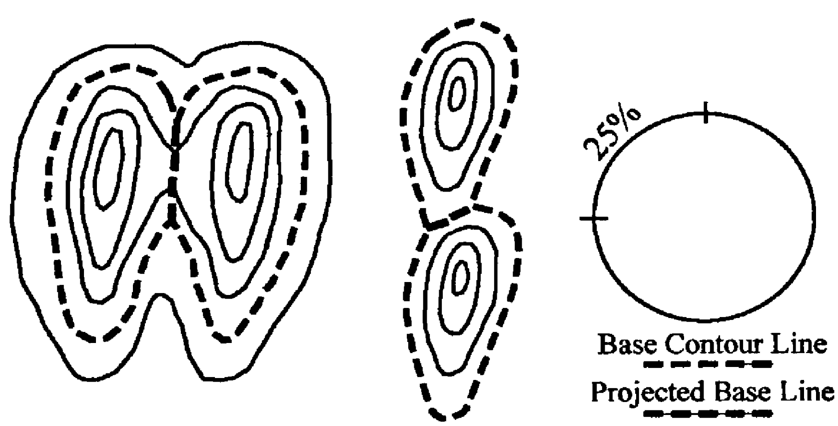



Figure 2. Fused Drumlin Illustration.

Contour lines requiring projection much greater that 25% often were somewhat more irregular than the higher contours and therefore did not appear to represent an accurate

form of the drumlin (Mills 1980, 2237). Additionally, relatively small lateral irregularities were ignored when drawing drumlin bases because they probably resulted from post-glacial erosion or deposition (Figure 3).

Figure 3. Lateral Irregularities.

Drumlins were first delineated on paper topographic maps because they are more easily seen in that format. After drumlin bases were delineated on the topographic maps, they were digitized onscreen using ArcGIS 8.2 (ESRI, 2002) from matching Digital Raster Graphics (DRGs) sources acquired from the Montana Natural Resource Information System (NRIS). The reason they were onscreen digitized was so that more precise morphometric measurements could be made. Once digitized, each drumlin was assigned an identification number for inclusion in an attribute table containing drumlin morphometrics.

**Drumlin Morphometrics** – All measurements were expressed in metric units. The morphometrics collected consisted of the following:

***Basic Metrics*:**

- Drumlin Base Contour Elevation ($DE_b$) - The base elevation contour (lowest contour exhibiting a streamline shape) indicated the lowest elevation of each drumlin. This contour defined drumlin areal extent.

- Drumlin Base Area ($DA_b$) – This metric was calculated as the area contained within the base contour elevation.
- Drumlin Base Perimeter ($DP_b$) – This was the total length of a drumlin base contour.
- Drumlin Centroid ($DC$) – This is the geometrical center of the area encompassed by a drumlin's highest contour to delineate the summit point. Drumlin centroid locations were recorded in UTM coordinates.
- Drumlin Summit Elevation ($DE_s$) – The point of highest elevation along a drumlin crest was indicated by a survey benchmark or, lacking such, one half the elevation of a contour interval was added to the highest contour ring elevation (Mills 1980, 22470; Francek and Blish 1991, 110).
- Drumlin Height ($DH$) – This metric reflected the elevation difference between a drumlin summit elevation and its base contour elevation.
- Drumlin Long Link Length ($DL_{ll}$) – The longer crest line was drawn from the summit elevation point to the base contour of each drumlin, intersecting through the points of maximum curvature of the majority of contours.
- Drumlin Short Link Length ($DL_{sl}$) – The shorter length segment was measured along the crest from the summit of each drumlin to its base contour in the same manner as the drumlin long link length.
- Drumlin Length ($DL$) – This metric was the entire length, which resulted from the addition of the long link crest length and the short link crest length. The subdivision of crest lines into two links connected at the drumlin summit is

desirable because some drumlin crest lines can veer in direction slightly, usually at or close to the summit.

- Drumlin Width (*DW*) – Width was measured at the widest part of the drumlin at right angles to the drumlin's long link axis.
- Drumlin Orientation (*DO*) – This metric expresses the angle located between the azimuth of a drumlin long link (measured along the line of descent and projected on to the mapping plane) from true east, which was the azimuth origin. True east was chosen so that the descriptive statistics would be more consistent. If true north were chosen in the Seeley/Swan Valley some drumlins would have been east of true north and some would have been west causing the range, average, standard deviation, etc. to be misrepresented in the descriptive statistics.

***Derived Metrics*:**

- Drumlin Long Link Slope ($DS_{ll}$) – This value was calculated by the following formula:

$$DS_{ll} = DH / DL_{ll}$$

- Drumlin Short Link Slope ($DS_{sl}$) – This value was calculated using the following formula:

$$DS_{sl} = DH / DL_{sl}$$

- Drumlin Lateral Slope ($DS_l$) – This value was reflected by the following formula:

$$DS_l = 2DH / DW$$

Lateral slope indicates how thin and steep drumlin sides are.

- Drumlin Volume (*DV*) – This metric expresses the quantity of fill material that overlies a drumlin's basal area. The volume was derived by the following formula:

$$DV = 2/3\pi(DL*DW*DH)$$

where *DV* is the volume of a half-ellipsoid, *DL* equals drumlin length, *DW* equals drumlin width, and *DH* equals drumlin height (Trenhaile 1975, 308). Trenhaile (1975) used the half-ellipsoid in this equation from the derivation that Reed, Galvin, and Miller (1962, 201-202) made which showing that drumlins closely approximate ellipsoidal forms.

- Drumlin Elongation (*L/W*) – This length/width ratio indicates the degree of drumlin streamlining. The ratio was calculated by the following formula:

$$L/W = DL / DW$$

- Drumlin K Value (*K*) – The drumlin *K* value can be used as an alternative to the drumlin elongation ratio and correlates closely with the drumlin elongation ratio (*L/W*) (Doornkamp and King 1971, 300; Trenhaile 1975, 305). The *K* value is obtained using the following formula:

$$K = DL^2\pi/4DA_b$$

- Drumlin Length/Height Ratio (*L/H*) – The *L/H* ratio was calculated by the following formula:

$$L/H = DL/DH$$

- Drumlin Width/Height Ratio (*W/H*) – The *W/H* ratio was calculated by the following formula:

$$W/H = DW/DH$$

- Drumlin Lee Slope/Stoss Slope Ratio (*L/S*) – The *L/S* ratio was calculated by the following formula:

$$L/S = DS_{ll}/DS_{sl}$$

- Drumlin Compactness Ratio (*DCR*) – This ratio expressed drumlin area to the area of a circle having its circumference equal to the drumlin's base perimeter. This metric was calculated in the IDRISI raster GIS program, which used the following formula:

$$DCR = \sqrt{(DA_b/Ac)}$$

  where $DA_b$ is the area of the polygon being calculated and $Ac$ is the area of a circle having the same perimeter as that of the polygon being calculated. A value of 1 is perfectly compact and a value of 0 is the least compact.

- Nearest-Neighbor Distance (*DNN*) – The distance between a given drumlin and its nearest-neighbor was calculated using a Visual Basic script written by Dr. M. Sawada (2002) to be used in ArcGIS.

**Drumlin Fields**

Drumlin fields are spatial groupings or swarms of individual drumlins. Drumlin field morphometrics apply only to the field as a whole and mainly deal with size, shape, and density. All measurements of drumlin field metrics were recorded using the metric system.

**Drumlin Field Morphometrics** - The drumlin field morphometrics collected consist of the following:

- Drumlin Field Area (*FA*) - The drumlin field area in square meters was determined by connecting the outermost drumlins of the drumlin field with straight line segments, which comprised the drumlin field boundary.
- Average Drumlin Field Length (*FL*) – Average drumlin field length in meters was estimated; the estimation provided a field "scale" so that comparisons between the two Montana fields could be made.
- Average Drumlin Field Width (*FW*) – Average drumlin field width in meters was estimated; the estimation provided a field "scale" so that comparisons could be made between the two Montana drumlin fields.
- Number of Drumlins ($F_dN$) - The number of drumlins in each field was counted to calculate drumlin densities.
- Number of Drumlin Twins ($F_dT$) – The number of fused drumlins (adjacent drumlins sharing the same contour base) was noted.
- Drumlin Field Compactness Ratio (*FCR*) – This ratio expresses the drumlin field area to the area of a circle having its circumference equal to the drumlin field perimeter. This was used to determine how compact the drumlin field was. This metric was calculated in the IDRISI raster GIS program, which used the following formula:

$$DCR = \sqrt{(FA/Ac)}$$

where *FA* is the area of the polygon being calculated and *Ac* is the area of a circle having the same perimeter as that of the polygon being calculated. A value of 1 is perfectly compact and a value of 0 is least compact.

- Drumlin Density per Square Kilometer ($F_dD$) - Drumlin density per square kilometer was calculated using the formula:

$$F_dD = F_dN / (FA / 1,000,000)$$

where 1,000,000 is the number of square meters in a kilometer.

- Percent Area Drumlins ($F_dP$) - The percent area consisting of drumlins was calculated by dividing the sum of drumlin basal areas by the drumlin field area. This indicated how much of a field actually consisted of drumlins.

**Data Analysis**

**Frequency Distributions -** Frequency distributions and normal probability plots (P-Plots) were derived for each metric (Appendices F and G). Upon review of the frequency distributions, I noticed that some metrics lacked normal distribution. To achieve more normal distributions, I performed base-10 logarithmic transformations on the data. The logarithmic values were entered into frequency distributions and P-Plots (Appendices H and I).

**Descriptive Statistics -** Descriptive statistics were run on the metrics. The descriptive statistics include: minimum value, maximum value, mean value ($\mu$), standard deviation ($\sigma$), coefficient of variance (*cv*), skewness, and kurtosis (Tables 1, 2, 4, 5, and Appendix E). Once the descriptive statistics were derived, I made comparison graphs, which compared the data ranges and mean values for the two Montana drumlin fields (Appendices I & J).

**Difference of Means *t-test* -** A two-sample difference of means *t-test* was run, using the Statistical Package for the Social Sciences (SPSS) computer software program,

to determine whether statistically significant differences existed for each metric between the Montana drumlin fields.

**Correlation Matrices** - I produced a correlation matrix for each Montana drumlin field, using the SPSS software program, to look at the interrelationships among the metrics (Tables 9-12, Appendix L). Base-10 logarithmically transformed data were used.

**Principal Component Analysis (PCA)** - A principal component analysis was performed in the SPSS software program to determine which metrics best describe valley drumlins for the two Montana drumlin fields. Principal component analysis can be used in two ways. (1) The new principal components can be used alone as new variables to reduce the total number of original variables or (2) a subset of metrics can be extracted based on principal component loading or weighting values to reduce the total number of original variables (Dunteman 1989, 9). In this study I used the second application and selected a subset of metrics from the original large set of metrics. These subset metrics were assumed to represent the metrics that best describe valley drumlins. The PCA results were then compared against each of the two Montana drumlin fields and are shown in Tables 13 and 18. PCA was performed on each field for each definition. Additionally, the Seeley/Swan Valley data for delineation definition #1 was combined with the Tobacco Plains/Stillwater Valley data for delineation definition #1. This was also done for delineation definition #2. PCA was then run on these two combined data sets. In this study, only the top principal components having eigenvalues greater than, or equal to, 0.7 (Dunteman 1989, 51) were used. This criterion retained the top five, out of a potential seventeen, principal components of the two Montana fields. A subset of five

metrics was then selected from the retained five principal components based on principal component loadings or weights. One metric was selected to represent each retained principal component. Thus, the metric that had the highest loading or weight for the first principal component was selected to represent that component. Likewise, the metric that had the highest loading or weight for the second principal component, provided it had not been chosen in the previous component, was selected to represent the second component (Dunteman 1989, 50). This procedure was repeated five times, once for each retained principal component. The subset of metrics was assumed to best describe variation among valley drumlins.

**Drumlin Distribution -** The spatial distributions of the drumlins in the two Montana drumlin fields were examined using drumlin density and nearest-neighbor analysis.

***Drumlin Density* -** I analyzed drumlin density in two different ways. The first took the form of drumlin density per square kilometer ($km^2$) by dividing the number of drumlins ($F_dN$) by the drumlin field area ($FA$) in square kilometers. The second took the form of percent area of drumlins, which was simply the percent of the drumlin field area that was taken up by the sum of all the drumlin areas in that drumlin field.

***Nearest-Neighbor Analysis* -** I also performed a nearest-neighbor analysis for the two Montana drumlin fields to determine whether the drumlins were uniformly distributed, randomly distributed, or clustered (Tables 21 & 22). The distances to each drumlin's nearest neighbor were measured from the drumlin summit points. The nearest-neighbor analysis was performed using a Visual Basic script written by Dr. M. Sawada (2002) for use in ArcGIS (the script can be downloaded from ESRI's website

(www.esri.com)). With this script the distance to each drumlin was measured and added to an attribute table, the observed averaged distance was calculate, the expected average distance was calculated, the nearest-neighbor index was calculated, the standard deviation was calculated, and the standard z-value was calculated. The observed average nearest-neighbor distance ($D_{obs}$) was calculated using the formula:

$$D_{obs} = \frac{\sum_{i=1}^{n} d_i}{n}$$

where $d_i$ represents the nearest-neighbor distance for point $i$ in the point pattern and $n$ is the number of drumlin summit points. The expected average nearest-neighbor distance ($D_{exp}$) was calculated using the formula:

$$D_{exp} = 0.5\sqrt{\frac{A}{n}}$$

where $A$ represents drumlin field area and $n$ is the number of drumlin summit points. The nearest-neighbor index ($NNI$) was calculated using the formula:

$$NNI = \frac{D_{obs}}{D_{exp}}$$

The standard deviation ($SD$) was calculated using the formula:

$$SD = \sqrt{\left(\frac{1}{4\tan^{-1}1} - \frac{1}{4}\right)\frac{A}{n^2}}$$

where $A$ represents drumlin field area and $n$ is the number of drumlin summit points.

The standard z-value ($Z$) was calculated using the formula:

$$Z = \frac{(D_{obs} - D_{exp})}{SD}$$

A *NNI* of 0.0 represents a perfect cluster of points, < 1 represents points that are "clustered," >1 represents points that "dispersed" and 2.15 is perfectly dispersed.

**Cartographic Analysis** – A map showing drumlin axes and drumlin ID can be found in Appendix C.

Choropleth drumlin density maps which showed drumlin density per square kilometer are in Appendix M. In these choropleth maps the drumlin polygons were colored differently to represent their drumlin density. Drumlin density for these choropleth maps was derived by overlaying a grid containing 1 $km^2$ cells over the drumlin fields and counting the number of drumlin summit points that fell within each square kilometer.

Maps showing the maximum 10% and minimum 10% of each metric's value distribution were made to reveal spatial patterns. Upon examination, however, these maps proved to be inconclusive and were omitted.

# CHAPTER 4

# RESULTS

From this point on I refer to the two Montana drumlin fields (Seeley/Swan Valley and Tobacco Plains/Stillwater Valley) simply as Seeley/Swan and Tobacco. All tabular data appear in Tables 1-8 and Appendix E. Histograms and P-Plots are placed in Appendices F-I.

## Frequency Distribution

**Frequency Distribution Using Drumlin Delineation Definition #1 –** Frequency distributions and P-Plots showed that, *DW*, *DO*, and *DCR* were normally distributed or approximately so, for the Seeley/Swan drumlins. All other metric distributions were positively skewed except for *L/S*, which was negatively skewed. For the Tobacco drumlins, only *DO* was found to have a normal distribution. All other metrics were positively skewed except for *DCR* and *L/S*, which were negatively skewed. Logarithmic transformations of all skewed data produced normal distributions for both fields.

**Frequency Distribution Using Drumlin Delineation Definition #2 –** Frequency distributions and P-Plots showed that, *DW*, *DO*, *DCR*, *W/H*, and *L/S* were normally distributed or approximately so, for the Seeley/Swan drumlins. All other metric distributions were positively skewed. For the Tobacco drumlins, only *DCR* was found to

have a normal distribution. All other metrics were positively skewed. Logarithmic transformations of the skewed data produced normal distributions for both fields.

**Frequency Distribution Comparison of the Two Delineation Definitions** – For definition #1 the Seeley/Swan field displayed normal distributions for *DW*, *DO*, and *DCR*. Definition #2 also showed the same three metrics to be normally distributed but also showed normal distributions for the *W/H* and *L/S* metrics. For the Tobacco field only the metric *DO* was normally distributed for definition #1. For definition #2 in the Tobacco field only the metric *DCR* was normally distributed.

**Descriptive Statistics and t-tests**

Descriptive statistics were calculated for the drumlin metrics. The resulting values are presented in Tables 1, 2, 4, and 5 and are also placed at the top of the data tables in Appendix E. Graphs showing side-by-side comparisons between the two Montana drumlin fields can be found in Appendices J and K. Difference of means *t-test* results are presented in Tables 3, 6, 7, and 8. By examining Tables 1-8 and Appendices J and K, I compared the two Montana drumlin fields.

**Descriptive Statistics Using Drumlin Delineation Definition #1** – All Tobacco drumlin metrics, with the exception of $DL_{ll}$, *L/H*, and *L/S*, had larger data ranges than those from Seeley/Swan. The results showed that the metrics *DL*, *DW*, *DH*, $DA_b$, $DL_{ll}$, $DL_{sl}$, $DS_l$, *K*, *L/W*, *L/H*, and *DV* had larger average values for the Tobacco field. The Seeley/Swan field had larger average values for $DS_{ll}$, $DS_{sl}$, *W/H*, *L/S*, and *DCR*. The metric *L/S*, however, was nearly identical for both drumlin fields. All basic metrics (*DL*, *DH*, *DW*, $DA_b$, $DL_{ll}$, $DL_{sl}$, and *DO*) showed a statistically significant difference at the .05 level between the two Montana fields.

| | Min | Max | Range | Mean($\mu$) | STDEV($\sigma$) | Skewness | Kurtosis | Coefficient of Variance($cv$) |
|---|---|---|---|---|---|---|---|---|
| DL (m) | 216.9 | 1,275.4 | 1,058.5 | 535.1 | 229.3 | 1.06 | 0.82 | 42.86 |
| DW (m) | 90.6 | 314.8 | 224.1 | 182.9 | 48.4 | 0.53 | 0.14 | 26.45 |
| DH (m) | 12.8 | 27.4 | 14.6 | 16.7 | 2.7 | 1.80 | 3.79 | 16.13 |
| $DA_b$ (m$^2$) | 18,652.3 | 260,509.0 | 241,856.7 | 78,577.9 | 51,523.6 | 1.63 | 2.76 | 65.57 |
| $DL_{ll}$ (m) | 125.5 | 986.4 | 861.0 | 319.5 | 160.3 | 1.56 | 3.34 | 50.18 |
| $DL_{sl}$ (m) | 78.7 | 501.4 | 422.8 | 215.7 | 89.4 | 1.13 | 1.07 | 41.45 |
| DO (°) | 224.00 | 305.53 | 81.5 | 257.94 | 13.62 | 0.74 | 1.50 | 5.28 |
| $DS_l$ | 0.097 | 0.355 | 0.26 | 0.196 | 0.060 | 0.641 | -0.167 | 30.872 |
| $DS_{ll}$ | 0.017 | 0.132 | 0.12 | 0.064 | 0.029 | 0.525 | -0.631 | 44.902 |
| $DS_{sl}$ | 0.030 | 0.232 | 0.20 | 0.090 | 0.038 | 0.995 | 1.456 | 42.033 |
| DCR | 0.492 | 0.784 | 0.29 | 0.640 | 0.066 | -0.239 | -0.662 | 10.365 |
| K | 1.50 | 6.17 | 4.68 | 3.07 | 1.04 | 0.80 | 0.16 | 33.95 |
| L/W | 1.54 | 5.26 | 3.71 | 2.93 | 0.94 | 0.73 | -0.22 | 32.24 |
| L/H | 11.86 | 83.69 | 71.83 | 32.71 | 14.46 | 0.94 | 0.60 | 44.20 |
| W/H | 5.64 | 20.65 | 15.01 | 11.22 | 3.47 | 0.70 | 0.20 | 30.94 |
| L/S | 0.25 | 1.00 | 0.75 | 0.72 | 0.19 | -0.61 | -0.47 | 26.03 |
| DV (m$^3$) | 7.67E+04 | 1.35E+06 | 1.27E+06 | 3.72E+05 | 2.55E+05 | 1.59 | 2.51 | 68.59 |

For the metric DO 0° is located at due East

Table 1. Seeley/Swan Valley Descriptive Statistics Definition #1.

| | Min | Max | Range | Mean($\mu$) | STDEV($\sigma$) | Skewness | Kurtosis | Coefficient of Variance($cv$) |
|---|---|---|---|---|---|---|---|---|
| DL (m) | 171.2 | 1,433.5 | 1,262.3 | 636.9 | 216.2 | 0.90 | 1.16 | 33.94 |
| DW (m) | 70.8 | 422.4 | 351.6 | 202.3 | 68.4 | 0.77 | 0.17 | 33.84 |
| DH (m) | 12.8 | 51.8 | 39.0 | 20.3 | 7.5 | 2.04 | 4.76 | 36.74 |
| $DA_b$ (m$^2$) | 12,936.0 | 355,242.0 | 342,306.0 | 102,827.2 | 63,958.1 | 1.51 | 2.39 | 62.20 |
| $DL_{ll}$ (m) | 98.5 | 908.4 | 809.9 | 380.1 | 147.0 | 1.09 | 1.23 | 38.67 |
| $DL_{sl}$ (m) | 72.7 | 647.9 | 575.2 | 256.8 | 90.6 | 1.13 | 2.45 | 35.26 |
| DO (°) | 23.68 | 97.80 | 74.1 | 62.03 | 10.87 | 0.28 | 1.32 | 17.52 |
| $DS_l$ | 0.078 | 0.548 | 0.47 | 0.214 | 0.079 | 1.220 | 2.274 | 36.719 |
| $DS_{ll}$ | 0.020 | 0.155 | 0.13 | 0.059 | 0.023 | 1.173 | 1.785 | 40.109 |
| $DS_{sl}$ | 0.028 | 0.282 | 0.25 | 0.086 | 0.037 | 1.989 | 6.345 | 42.669 |
| DCR | 0.340 | 0.735 | 0.39 | 0.593 | 0.071 | -0.550 | 0.810 | 12.019 |
| K | 1.75 | 11.21 | 9.46 | 3.49 | 1.33 | 2.26 | 8.56 | 38.16 |
| L/W | 1.70 | 10.65 | 8.95 | 3.33 | 1.23 | 2.21 | 8.60 | 37.14 |
| L/H | 11.23 | 78.38 | 67.15 | 33.27 | 11.88 | 0.96 | 1.65 | 35.72 |
| W/H | 3.65 | 25.51 | 21.86 | 10.55 | 3.74 | 1.01 | 1.71 | 35.41 |
| L/S | 0.32 | 0.99 | 0.67 | 0.71 | 0.18 | -0.44 | -0.78 | 25.08 |
| DV (m$^3$) | 5.22E+04 | 5.01E+06 | 4.96E+06 | 6.51E+05 | 6.46E+05 | 3.14 | 14.78 | 99.14 |

For the metric DO 0° is located at due East

Table 2. Tobacco Plains/Stillwater Valley Descriptive Statistics Definition #1.

| Metric | *t* | *df* | P-value (2-tailed) | Sig. Diff. @ .05 level |
|---|---|---|---|---|
| DL | 4.01 | 241 | < 0.001 | Yes |
| DW | -2.06 | 241 | 0.041 | Yes |
| DH | -5.30 | 241 | < 0.001 | Yes |
| $DA_b$ | 3.55 | 241 | < 0.001 | Yes |
| $DL_{ll}$ | -3.78 | 241 | < 0.001 | Yes |
| $DL_{sl}$ | -3.91 | 241 | < 0.001 | Yes |
| DO | 9.81 | 241 | < 0.001 | Yes |
| $DS_l$ | -1.75 | 241 | 0.082 | No |
| $DS_{ll}$ | 0.97 | 241 | 0.335 | No |
| $DS_{sl}$ | 0.73 | 241 | 0.468 | No |
| DCR | 5.20 | 241 | < 0.001 | Yes |
| K | -2.87 | 241 | 0.004 | Yes |
| L/W | -2.93 | 241 | 0.004 | Yes |
| L/H | -0.89 | 241 | 0.375 | No |
| W/H | 1.75 | 241 | 0.082 | No |
| L/S | 0.67 | 241 | 0.506 | No |
| DV | 4.80 | 241 | < 0.001 | Yes |

*df* = degrees of freedom

Table 3. t-test Results Definition #1.

The only metrics that showed no significant differences at the .05 level between the two drumlin fields were $DS_l$, $DS_{ll}$, $DS_{sl}$, *L/H*, *W/H*, and *L/S*. In regard to drumlin orientation, the distal ends of the Tobacco drumlins were directed to the southeast, whereas the distal ends of the Seeley/Swan drumlins were more or less north northwest. The orientations differed by almost 180 degrees.

**Descriptive Statistics Using Drumlin Delineation Definition #2** – All Tobacco drumlin metrics, with the exceptions of $DL_{ll}$, $DS_{ll}$, $DS_{sl}$, *L/H*, and *L/S*, had larger data ranges than those from Seeley/Swan. The results showed that metrics *DL*, *DW*, *DH*, $DA_b$, $DL_{ll}$, $DL_{sl}$, $DS_l$, *K*, *L/W*, *L/H*, *W/H*, *L/S*, and *DV* had larger average values for the Tobacco field. The Seeley/Swan field had larger average values for $DS_{ll}$, $DS_{sl}$, and *DCR*. The metric *L/S*, however, was nearly identical for both drumlin fields. All of the basic metrics (*DL*, *DW*, *DH*, $DA_b$, $DL_{ll}$, $DL_{sl}$, and *DO*) showed a statistically significant difference

| | Min | Max | Range | Mean(μ) | STDEV(σ) | Skewness | Kurtosis | Coefficient of Variance(*cv*) |
|---|---|---|---|---|---|---|---|---|
| DL (m) | 155.8 | 1,275.4 | 1,119.7 | 501.1 | 230.5 | 1.09 | 0.90 | 46.01 |
| DW (m) | 63.5 | 314.8 | 251.3 | 170.4 | 54.5 | 0.33 | -0.20 | 31.96 |
| DH (m) | 6.7 | 27.4 | 20.7 | 15.1 | 4.0 | 0.14 | 0.58 | 26.23 |
| $DA_b$ ($m^2$) | 9,573.1 | 260,509.0 | 250,935.9 | 70,354.6 | 51,656.0 | 1.59 | 2.72 | 73.42 |
| $DL_{ll}$ (m) | 91.8 | 986.4 | 894.6 | 298.7 | 156.5 | 1.59 | 3.51 | 52.40 |
| $DL_{sl}$ (m) | 63.9 | 501.4 | 437.5 | 202.4 | 91.1 | 1.09 | 1.01 | 41.45 |
| DO (°) | 224.00 | 305.53 | 81.5 | 258.38 | 14.15 | 0.51 | 1.04 | 5.47 |
| $DS_l$ | 0.070 | 0.355 | 0.28 | 0.190 | 0.060 | 0.510 | -0.160 | 32.320 |
| $DS_{ll}$ | 0.020 | 0.330 | 0.31 | 0.080 | 0.060 | 1.820 | 3.920 | 67.670 |
| $DS_{sl}$ | 0.030 | 0.470 | 0.44 | 0.120 | 0.080 | 1.920 | 3.830 | 68.730 |
| DCR | 0.490 | 0.784 | 0.29 | 0.640 | 0.070 | -0.100 | -0.070 | 10.670 |
| K | 1.50 | 6.17 | 4.68 | 3.12 | 1.06 | 0.73 | 0.01 | 33.86 |
| L/W | 1.54 | 5.67 | 4.12 | 2.96 | 0.96 | 0.70 | -0.25 | 32.51 |
| L/H | 5.19 | 83.69 | 78.50 | 28.59 | 15.48 | 0.87 | 0.51 | 54.16 |
| W/H | 2.12 | 20.65 | 18.54 | 9.77 | 4.27 | 0.28 | -0.22 | 43.70 |
| L/S | 0.25 | 1.00 | 0.75 | 0.72 | 0.18 | -0.57 | -0.46 | 25.48 |
| DV ($m^3$) | 2.26E+04 | 1.35E+06 | 1.32E+06 | 3.15E+05 | 2.56E+05 | 1.59 | 2.79 | 81.30 |

For the metric DO 0° is located at due East

Table 4. Seeley/Swan Valley Descriptive Statistics Definition #2.

| | Min | Max | Range | Mean(μ) | STDEV(σ) | Skewness | Kurtosis | Coefficient of Variance(*cv*) |
|---|---|---|---|---|---|---|---|---|
| DL (m) | 171.2 | 1,433.5 | 1,262.3 | 602.6 | 217.2 | 0.97 | 1.25 | 36.04 |
| DW (m) | 64.1 | 422.4 | 358.3 | 190.4 | 70.1 | 0.79 | 0.30 | 36.80 |
| DH (m) | 7.0 | 51.8 | 44.8 | 18.5 | 8.0 | 1.63 | 3.76 | 43.16 |
| $DA_b$ ($m^2$) | 12,936.0 | 355,242.0 | 342,306.0 | 92,921.7 | 63,210.9 | 1.68 | 2.81 | 68.03 |
| $DL_{ll}$ (m) | 98.5 | 908.4 | 809.9 | 356.7 | 147.4 | 1.14 | 1.42 | 41.32 |
| $DL_{sl}$ (m) | 72.7 | 647.9 | 575.2 | 245.9 | 88.7 | 1.22 | 2.70 | 36.08 |
| DO (°) | 23.68 | 98.69 | 75.0 | 62.72 | 11.24 | 0.45 | 1.17 | 17.92 |
| $DS_l$ | 0.080 | 0.550 | 0.47 | 0.200 | 0.080 | 1.260 | 2.440 | 37.940 |
| $DS_{ll}$ | 0.020 | 0.155 | 0.14 | 0.060 | 0.020 | 1.270 | 2.130 | 40.980 |
| $DS_{sl}$ | 0.030 | 0.280 | 0.25 | 0.080 | 0.040 | 1.980 | 6.410 | 45.240 |
| DCR | 0.340 | 0.780 | 0.44 | 0.590 | 0.070 | -0.370 | 0.590 | 12.590 |
| K | 1.75 | 11.21 | 9.48 | 3.53 | 1.34 | 2.05 | 7.08 | 38.03 |
| L/W | 1.69 | 10.65 | 8.97 | 3.36 | 1.25 | 2.01 | 7.05 | 37.10 |
| L/H | 11.23 | 83.00 | 71.77 | 35.46 | 13.06 | 0.94 | 1.51 | 36.82 |
| W/H | 3.65 | 25.51 | 21.86 | 11.12 | 4.02 | 0.89 | 0.93 | 36.11 |
| L/S | 0.32 | 1.02 | 0.70 | 0.73 | 0.18 | -0.51 | -0.67 | 24.53 |
| DV ($m^3$) | 5.22E+04 | 5.01E+06 | 4.96E+06 | 6.51E+05 | 6.46E+05 | 3.14 | 14.78 | 99.14 |

For the metric DO 0° is located at due East

Table 5. Tobacco Plains/Stillwater Valley Descriptive Statistics Definition #2.

| Metric | t | *df* | P-value (2-tailed) | Sig. Diff. @ .05 level |
|---|---|---|---|---|
| DL | -4.55 | 296 | < 0.001 | Yes |
| DW | -2.37 | 296 | 0.019 | Yes |
| DH | -4.07 | 296 | < 0.001 | Yes |
| $DA_b$ | -3.91 | 296 | < 0.001 | Yes |
| $DL_{ll}$ | -5.04 | 296 | < 0.001 | Yes |
| $DL_{sl}$ | -4.79 | 296 | < 0.001 | Yes |
| DO | 10.01 | 296 | < 0.001 | Yes |
| $DS_l$ | -1.52 | 296 | 0.130 | No |
| $DS_{ll}$ | 4.78 | 296 | < 0.001 | Yes |
| $DS_{sl}$ | 5.13 | 296 | < 0.001 | Yes |
| DCR | 5.48 | 296 | < 0.001 | Yes |
| K | -3.04 | 296 | 0.003 | Yes |
| L/W | -3.17 | 296 | 0.002 | Yes |
| L/H | -5.07 | 296 | < 0.001 | Yes |
| W/H | -3.34 | 296 | 0.001 | Yes |
| L/S | -0.32 | 296 | 0.749 | No |
| DV | -4.50 | 296 | < 0.001 | Yes |

*df* = degrees of freedom

Table 6. t-test Results Definition #2.

at the .05 level between the two Montana fields. Furthermore, the only metrics that showed no significant difference at the .05 level between the two drumlin fields were $DS_l$, and *L/S.*

**Descriptive Statistic Comparison of the Two Delineation Definitions** – A comparison of the two definitions for the Seeley/Swan drumlins (Table 7) showed that the metrics *DH*, $DL_{ll}$, $DS_{ll}$, $DS_{sl}$, *L/H*, *W/H*, and *DV* were significantly different at the .05 level for the two drumlin delineation definitions. For the Tobacco drumlins a comparison of the two definitions showed that only the metrics *DH* and *DV* differed significantly at the .05 level between the two drumlin delineation definitions (Table 8). Finally, all basic metrics except $DL_{ll}$ for the Seeley/Swan comparison and *DH* for both comparisons showed no statistically significant difference at the .05 level between the two definitions for both fields.

| Metric | t | *df* | P-value (2-tailed) | Sig. Diff. @ .05 level |
|---|---|---|---|---|
| DL | 1.36 | 217 | 0.175 | No |
| DW | 1.77 | 217 | 0.078 | No |
| DH | 4.25 | 217 | < 0.001 | Yes |
| $DA_b$ | 1.94 | 217 | 0.054 | No |
| $DL_{II}$ | 2.28 | 217 | 0.024 | Yes |
| $DL_{sl}$ | 1.41 | 217 | 0.159 | No |
| DO | -2.94 | 217 | 0.769 | No |
| $DS_I$ | 0.69 | 217 | 0.489 | No |
| $DS_{II}$ | -2.65 | 217 | 0.009 | Yes |
| $DS_{sl}$ | -2.90 | 217 | 0.004 | Yes |
| DCR | -0.02 | 217 | 0.985 | No |
| K | -0.35 | 217 | 0.730 | No |
| L/W | -0.26 | 217 | 0.793 | No |
| L/H | 2.86 | 217 | 0.005 | Yes |
| W/H | 2.74 | 217 | 0.007 | Yes |
| L/S | 0.15 | 217 | 0.881 | No |
| DV | 2.90 | 217 | 0.004 | Yes |

*df* =degrees of freedom

Table 7. Seeley/Swan Valley t-test Definition #1 & #2 Comparison.

| Metric | t | *df* | P-value (2-tailed) | Sig. Diff. @ .05 level |
|---|---|---|---|---|
| DL | 1.58 | 322 | 0.115 | No |
| DW | 1.53 | 322 | 0.128 | No |
| DH | 3.11 | 322 | 0.002 | Yes |
| $DA_b$ | 1.93 | 322 | 0.055 | No |
| $DL_{II}$ | 1.68 | 322 | 0.094 | No |
| $DL_{sl}$ | 1.15 | 322 | 0.253 | No |
| DO | -0.56 | 322 | 0.579 | No |
| $DS_I$ | 1.25 | 322 | 0.212 | No |
| $DS_{II}$ | 1.11 | 322 | 0.267 | No |
| $DS_{sl}$ | 1.75 | 322 | 0.081 | No |
| DCR | -0.10 | 322 | 0.919 | No |
| K | -0.30 | 322 | 0.768 | No |
| L/W | -0.27 | 322 | 0.785 | No |
| L/H | -1.46 | 322 | 0.146 | No |
| W/H | -1.25 | 322 | 0.212 | No |
| L/S | -0.96 | 322 | 0.337 | No |
| DV | 1.97 | 322 | 0.008 | Yes |

*df* = degrees of freedom

Table 8. Tobacco Plains/Stillwater Valley t-test Definition #1 & #2 Comparison.

**Pearson's Correlation Coefficients**

Pearson's correlation coefficients were calculated using base-10 logarithmic transformations of the metrics and are presented as correlation matrices in Tables 9-12. The correlation matrices allowed relationships between metrics to be studied.

**Pearson's Correlation Coefficients Using Drumlin Delineation Definition #1 –** In examination of the correlation matrices in Tables 9 and 10, it can be seen that there were commonly strong correlations ($\geq .90$) for the two Montana fields. The strong correlations existed between *DL and* $DL_{II}$, $DA_b$ *and DV*, $DS_I$ *and W/H*, $DS_{II}$ *and L/H*, *DCR and K*, *DCR and L/W*, and *K and L/W*. The *DL and* $DL_{II}$ correlation was seen because the *DL* metric and the $DL_{II}$ metric are both a measure of length. The $DA_b$ *and DV* correlation was most likely seen because area is two dimensional size indicator and volume is a three dimensional size indicator, both of which depend on length and width to achieve their product. The $DS_I$ *and W/H* had a perfect inverse correlation because the formulas used to derive the two metrics were identical with the exception of the multiplication of drumlin height by a value of two in the $DS_I$ formula. The $DS_{II}$ *and L/H* correlation was seen because both are indications of slope. The correlations between *DCR and K*, *DCR and L/W*, and *K and L/W* are all interrelated because they all express either elongation (*L/W* and *K*) or, inversely, compaction (*DCR*).

**Pearson's Correlation Coefficients Using Drumlin Delineation Definition #2 –** In examination of the correlation matrices in Tables 11 and 12, common strong correlations ($\geq .90$) for the two Montana fields were observed. These correlations existed between *DL and* $DL_{II}$, $DA_b$ *and DV*, $DS_I$ *and W/H*, $DS_{II}$ *and L/H*, $DS_{sI}$ *and L/H*, *DCR and K*, and *K and L/W*. The *DL and* $DL_{II}$ correlation was seen because the *DL* and $DL_{II}$

| | $DL$ | $DW$ | $DH$ | $DA_b$ | $DL_{ll}$ | $DL_{sl}$ | $DS_l$ | $DS_{ll}$ | $DS_{sl}$ | $DCR$ | $K$ | $L/W$ | $L/H$ | $W/H$ | $L/S$ | $DV$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *DL | 1 | | | | | | | | | | | | | | | |
| *DW | *0.64 | 1 | | | | | | | | | | | | | | |
| *DH | 0.01 | -0.02 | 1 | | | | | | | | | | | | | |
| $DA_b$ | *0.93 | *0.85 | -0.01 | 1 | | | | | | | | | | | | |
| $DL_{ll}$ | *0.97 | *0.58 | 0.02 | *0.89 | 1 | | | | | | | | | | | |
| $DL_{sl}$ | *0.88 | *0.62 | -0.02 | *0.86 | *0.74 | 1 | | | | | | | | | | |
| $DS_l$ | *-0.55 | *-0.88 | *0.49 | *-0.74 | *-0.49 | *-0.55 | 1 | | | | | | | | | |
| *$DS_{ll}$ | *-0.93 | *-0.56 | *0.29 | *-0.85 | *-0.95 | *-0.72 | *0.63 | 1 | | | | | | | | |
| *$DS_{sl}$ | *-0.82 | *-0.59 | *0.36 | *-0.80 | *-0.69 | *-0.94 | *0.68 | *0.77 | 1 | | | | | | | |
| DCR | *-0.72 | -0.05 | -0.01 | *-0.47 | *-0.74 | *-0.57 | 0.04 | *0.71 | *0.53 | 1 | | | | | | |
| K | *0.77 | 0.02 | 0.03 | *0.49 | *0.78 | *0.62 | -0.01 | *-0.74 | *-0.57 | *-0.93 | 1 | | | | | |
| *L/W | *0.76 | -0.02 | 0.03 | *0.49 | *0.77 | *0.61 | 0.03 | *-0.72 | *-0.56 | *-0.90 | *0.97 | 1 | | | | |
| *L/H | *0.94 | *0.61 | *-0.33 | *0.88 | *0.91 | *0.84 | *-0.69 | *-0.97 | *-0.90 | *-0.68 | *0.71 | *0.70 | 1 | | | |
| *W/H | *0.55 | *0.88 | *-0.49 | *0.74 | *0.49 | *0.55 | *-1.00 | *-0.63 | *-0.68 | -0.04 | 0.01 | -0.03 | *0.69 | 1 | | |
| *L/S | *0.30 | 0.06 | 0.05 | 0.21 | *0.52 | -0.18 | -0.03 | *-0.49 | 0.18 | *-0.36 | *0.36 | *0.34 | *0.27 | 0.03 | 1 | |
| DV | *0.92 | *0.83 | 0.23 | *0.97 | *0.88 | *0.83 | *-0.61 | *-0.77 | *-0.70 | *-0.49 | *0.51 | *0.49 | *0.79 | *0.61 | 0.23 | 1 |

* = Coefficients significant at the 0.01 level

All metrics were base-10 logarithmically transformed prior to analysis

Table 9. Seeley/Swan Valley Correlation Matrix Definition #1.

| | $DL$ | $DW$ | $DH$ | $DA_b$ | $DL_{ll}$ | $DL_{sl}$ | $DS_l$ | $DS_{ll}$ | $DS_{sl}$ | $DCR$ | $K$ | $L/W$ | $L/H$ | $W/H$ | $L/S$ | $DV$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *DL | 1 | | | | | | | | | | | | | | | |
| *DW | *0.55 | 1 | | | | | | | | | | | | | | |
| *DH | *0.38 | *0.40 | 1 | | | | | | | | | | | | | |
| $DA_b$ | *0.88 | *0.87 | *0.45 | 1 | | | | | | | | | | | | |
| $DL_{ll}$ | *0.96 | *0.50 | *0.37 | *0.82 | 1 | | | | | | | | | | | |
| $DL_{sl}$ | *0.87 | *0.53 | *0.33 | *0.80 | *0.70 | 1 | | | | | | | | | | |
| $DS_l$ | -0.19 | *-0.61 | *0.48 | *-0.44 | -0.16 | *-0.22 | 1 | | | | | | | | | |
| *$DS_{ll}$ | *-0.63 | -0.17 | *0.43 | *-0.45 | *-0.68 | *-0.41 | *0.53 | 1 | | | | | | | | |
| *$DS_{sl}$ | *-0.49 | -0.17 | *0.50 | *-0.38 | *-0.34 | *-0.65 | *0.59 | *0.72 | 1 | | | | | | | |
| DCR | *-0.49 | *0.40 | -0.02 | -0.04 | *-0.52 | *-0.32 | *-0.40 | *0.49 | *0.27 | 1 | | | | | | |
| K | *0.49 | *-0.44 | -0.02 | 0.01 | *0.50 | *0.34 | *0.41 | *-0.50 | *-0.33 | *-0.94 | 1 | | | | | |
| *L/W | *0.49 | *-0.46 | -0.01 | 0.02 | *0.49 | *0.36 | *0.43 | *-0.49 | *-0.35 | *-0.93 | *0.97 | 1 | | | | |
| *L/H | *0.62 | 0.18 | *-0.48 | *0.45 | *0.60 | *0.54 | *-0.59 | *-0.96 | *-0.89 | *-0.44 | *0.47 | *0.47 | 1 | | | |
| *W/H | 0.19 | *0.61 | *-0.48 | *0.44 | 0.16 | *0.22 | *-1.00 | *-0.53 | *-0.59 | *0.40 | *-0.41 | *-0.43 | *0.59 | 1 | | |
| *L/S | 0.20 | 0.01 | 0.08 | 0.10 | *0.47 | *-0.31 | 0.06 | *-0.39 | *0.35 | *-0.31 | *0.25 | 0.21 | 0.13 | -0.06 | 1 | |
| DV | *0.82 | *0.83 | *0.73 | *0.93 | *0.78 | *0.74 | -0.16 | -0.18 | -0.09 | -0.05 | 0.02 | 0.01 | 0.16 | 0.16 | 0.13 | 1 |

* = Coefficients significant at the 0.01 level

All metrics were base-10 logarithmically transformed prior to analysis

Table 10. Tobacco Plains/Stillwater Valley Correlation Matrix Definition #1.

metrics both measured length. The *$DA_b$ and DV* correlation was most likely seen because area is a two dimensional size indicator and volume is a three dimensional size indicator both of which use length and width to achieve their product. The *$DS_l$ and W/H* had a perfect inverse correlation because the formulas used to derive the two metrics were identical with the exception of the multiplication of drumlin height by a value of two in the $DS_l$ formula. The *$DS_{ll}$ and L/H* and *$DS_{sl}$ and L/H* correlation was seen because both are indications of slope. The correlations between *DCR and K* and *K and L/W* were

interrelated because they expressed either elongation (*L/W* and *K*) or, inversely, compaction (*DCR*).

| | *DL* | *DW* | *DH* | $DA_b$ | $DL_{ll}$ | $DL_{sl}$ | $DS_l$ | $DS_{ll}$ | $DS_{sl}$ | *DCR* | *K* | *L/W* | *L/H* | *W/H* | *L/S* | *DV* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *DL | 1 | | | | | | | | | | | | | | | |
| *DW | *0.69 | 1 | | | | | | | | | | | | | | |
| *DH | *0.30 | *0.44 | 1 | | | | | | | | | | | | | |
| $DA_b$ | *0.93 | *0.90 | *0.41 | 1 | | | | | | | | | | | | |
| $DL_{ll}$ | *0.97 | *0.63 | *0.28 | *0.88 | 1 | | | | | | | | | | | |
| $DL_{sl}$ | *0.91 | *0.71 | *0.31 | *0.89 | *0.79 | 1 | | | | | | | | | | |
| $DS_l$ | *-0.45 | *-0.65 | *0.40 | *-0.57 | *-0.40 | *-0.46 | 1 | | | | | | | | | |
| *$DS_{ll}$ | *-0.90 | *-0.70 | *-0.45 | *-0.88 | *-0.90 | **-0.76 | *0.33 | 1 | | | | | | | | |
| *$DS_{sl}$ | *-0.82 | *-0.75 | *-0.47 | *-0.86 | *-0.72 | *-0.90 | *0.36 | *0.87 | 1 | | | | | | | |
| DCR | *-0.61 | 0.04 | 0.00 | *-0.33 | *-0.66 | *-0.45 | -0.03 | *0.52 | *0.34 | 1 | | | | | | |
| K | *0.63 | -0.09 | -0.07 | *0.31 | *0.67 | *0.48 | 0.03 | *-0.49 | *-0.32 | *-0.91 | 1 | | | | | |
| *L/W | *0.64 | -0.11 | -0.05 | *0.33 | *0.67 | *0.49 | 0.07 | *-0.49 | *-0.34 | *-0.88 | *0.98 | 1 | | | | |
| *L/H | *0.90 | *0.74 | *0.47 | *0.90 | *0.86 | *0.83 | *-0.36 | *-0.98 | *-0.95 | *-0.47 | *0.44 | *0.45 | 1 | | | |
| *W/H | *0.61 | *0.89 | *0.55 | *0.80 | *0.55 | *0.63 | *-1.00 | *-0.79 | *-0.85 | 0.02 | -0.11 | -0.11 | *0.84 | 1 | | |
| *L/S | -0.22 | 0.04 | 0.01 | -0.10 | *-0.30 | 0.21 | -0.03 | *0.33 | -0.17 | *0.39 | *-0.37 | *-0.35 | -0.16 | 0.04 | 1 | |
| DV | *0.88 | *0.88 | *0.65 | *0.95 | *0.83 | *0.84 | *-0.35 | *-0.87 | *-0.86 | *-0.29 | *0.26 | *0.26 | *0.90 | *0.84 | -0.10 | 1 |

* = Coefficients significant at the 0.01 level
All metrics were base-10 logarithmically transformed prior to analysis

Table 11. Seeley/Swan Valley Correlation Matrix Definition #2.

**Tobacco Plains/Stillwater Valley Correlation Matrix Definition #2**

| | *DL* | *DW* | *DH* | $DA_b$ | $DL_{ll}$ | $DL_{sl}$ | $DS_l$ | $DS_{ll}$ | $DS_{sl}$ | *DCR* | *K* | *L/W* | *L/H* | *W/H* | *L/S* | *DV* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *DL | 1 | | | | | | | | | | | | | | | |
| *DW | *0.60 | 1 | | | | | | | | | | | | | | |
| *DH | *0.51 | *0.56 | 1 | | | | | | | | | | | | | |
| $DA_b$ | *0.88 | *0.89 | *0.60 | 1 | | | | | | | | | | | | |
| $DL_{ll}$ | *0.97 | *0.56 | *0.52 | *0.84 | 1 | | | | | | | | | | | |
| $DL_{sl}$ | *0.88 | *0.57 | *0.42 | *0.81 | *0.73 | 1 | | | | | | | | | | |
| $DS_l$ | -0.05 | *-0.42 | *0.52 | *-0.26 | -0.01 | -0.12 | 1 | | | | | | | | | |
| *$DS_{ll}$ | *-0.47 | -0.01 | *0.48 | *-0.25 | *-0.50 | *-0.32 | *0.54 | 1 | | | | | | | | |
| *$DS_{sl}$ | *-0.26 | 0.05 | *0.61 | -0.12 | -0.13 | -0.46 | *0.62 | *0.75 | 1 | | | | | | | |
| DCR | *-0.46 | *0.36 | -0.01 | -0.03 | *-0.48 | *-0.32 | *-0.38 | *0.48 | *0.26 | 1 | | | | | | |
| K | *0.42 | *-0.46 | -0.07 | -0.05 | *0.43 | *0.30 | *0.39 | *-0.52 | *-0.34 | *-0.91 | 1 | | | | | |
| *L/W | *0.42 | *-0.48 | -0.07 | -0.04 | *0.42 | *0.32 | *0.42 | *-0.50 | *-0.35 | *-0.91 | *0.98 | 1 | | | | |
| *L/H | *0.42 | -0.02 | *-0.57 | *0.21 | *0.38 | *0.40 | *-0.60 | *-0.96 | *-0.90 | *-0.42 | *0.48 | *0.47 | 1 | | | |
| *W/H | 0.05 | *0.42 | *-0.52 | *0.26 | 0.01 | 0.12 | *-1.00 | *-0.54 | *-0.62 | *0.38 | *-0.39 | *-0.42 | *0.60 | 1 | | |
| *L/S | -0.04 | -0.04 | -0.06 | -0.04 | -0.15 | 0.16 | -0.03 | 0.10 | *-0.20 | 0.04 | -0.01 | 0.00 | 0.02 | 0.03 | 1 | |
| DV | *0.83 | *0.85 | *0.83 | *0.94 | *0.80 | *0.73 | 0.04 | 0.02 | 0.18 | -0.04 | -0.05 | -0.06 | -0.09 | -0.04 | -0.05 | 1 |

* = Coefficients significant at the 0.01 level
All metrics were base-10 logarithmically transformed prior to analysis

Table 12. Tobacco Plains/Stillwater Valley Correlation Matrix Definition #2.

**Correlation Matrices Comparison of the Two Delineation Definitions** – The comparison of the two different correlation matrices for the Seeley/Swan field showed very similar results. Likewise, the comparison of the two different correlation matrices for the Tobacco field showed to be even more similar than the two for the Seeley/Swan

field. The two different drumlin delineation definitions seemed to have had little effect on the correlation results in the two fields.

**Principal Component Analysis (PCA)**

The PCA results are shown in tables (Tables 13-18). The metrics with the highest loadings or weights in each principal component are highlighted in grey and are assumed to be the metrics that best describe valley drumlins.

**PCA using Drumlin Delineation Definition #1** – The principal components for drumlin delineation definition #1 are shown in Tables 13 and 14. The metrics that represented the highest loadings for each principal component were *DL*, $DS_l$, *DH*, *L/S*, and *DO* for the Seeley/Swan and *DL*, *L/W*, *DH*, *L/S*, and *DO* for the Tobacco field. As a result they are considered to be the most descriptive metrics for each field. As can be seen the metrics representing the highest loadings for each principal component were the same for the two fields with the exception of principal component number two.

**PCA Using Drumlin Delineation Definition #2** – The principal components for drumlin delineation definition #2 are shown in Tables 15 and 16. The metrics that represented the highest loadings for each principal component were *DL*, *K*, $DS_l$, *L/S*, and $DS_{ll}$ for the Seeley/Swan and *DL*, *L/W*, $DS_l$, *L/S*, and *DO* for the Tobacco field. As a result they are considered to be the most descriptive metrics for each field. As can be seen the metrics representing the highest loadings for each principal component were the same for the two fields with the exception of principal component number two and five. However, metrics with the highest loading for principal component two were both measures of elongation.

**Principal Component Loadings**

| | PC 1 | PC 2 | PC 3 | PC 4 | PC 5 |
|---|---|---|---|---|---|
| DL | 0.983 | 0.131 | 0.102 | 0.066 | 0.023 |
| DW | 0.691 | -0.615 | 0.357 | 0.076 | -0.070 |
| DH | -0.152 | 0.374 | 0.736 | 0.534 | -0.098 |
| $DA_b$ | 0.945 | -0.193 | 0.222 | 0.088 | -0.015 |
| $DL_{ll}$ | 0.946 | 0.218 | 0.195 | -0.125 | -0.043 |
| $DL_{sl}$ | 0.882 | -0.050 | -0.107 | 0.432 | 0.145 |
| DO | -0.271 | 0.018 | 0.394 | -0.272 | 0.834 |
| $DS_l$ | -0.673 | 0.712 | 0.040 | 0.187 | 0.014 |
| $DS_{ll}$ | -0.952 | -0.094 | 0.040 | 0.284 | 0.011 |
| $DS_{sl}$ | -0.875 | 0.176 | 0.354 | -0.219 | -0.169 |
| DCR | -0.684 | -0.630 | 0.171 | 0.016 | 0.038 |
| K | 0.706 | 0.671 | -0.150 | 0.005 | 0.082 |
| L/W | 0.687 | 0.690 | -0.170 | 0.021 | 0.088 |
| L/H | 0.979 | -0.002 | -0.152 | -0.117 | 0.054 |
| W/H | 0.673 | -0.712 | -0.040 | -0.187 | -0.014 |
| L/S | -0.268 | -0.385 | -0.423 | 0.734 | 0.248 |
| DV | 0.894 | -0.089 | 0.388 | 0.199 | -0.038 |

| PC | Eigenvalues | % of Variance | Cumulative % |
|---|---|---|---|
| 1 | 9.952 | 58.541 | 58.541 |
| 2 | 3.155 | 18.558 | 77.099 |
| 3 | 1.497 | 8.808 | 85.907 |
| 4 | 1.371 | 8.064 | 93.970 |
| 5 | 0.845 | 4.968 | 98.939 |
| 6 | 0.141 | 0.827 | 99.766 |
| 7 | 0.038 | 0.222 | 99.988 |
| 8 | 2.062E-03 | 1.213E-02 | 100.000 |
| 9 | 1.098E-15 | 6.459E-15 | 100.000 |
| 10 | 6.577E-16 | 3.869E-15 | 100.000 |
| 11 | 2.961E-16 | 1.742E-15 | 100.000 |
| 12 | 1.503E-16 | 8.839E-16 | 100.000 |
| 13 | 1.011E-16 | 5.947E-16 | 100.000 |
| 14 | -5.534E-17 | -3.255E-16 | 100.000 |
| 15 | -3.782E-16 | -2.225E-15 | 100.000 |
| 16 | -6.109E-16 | -3.594E-15 | 100.000 |
| 17 | -1.278E-15 | -7.516E-15 | 100.000 |

All metrics were base-10 logarithmically transformed prior to analysis

Table 13. Seeley/Swan Valley Principal Component Table Definition #1.

**Principal Component Loadings**

| | PC 1 | PC 2 | PC 3 | PC 4 | PC 5 |
|---|---|---|---|---|---|
| DL | 0.954 | -0.099 | 0.281 | 0.025 | -0.004 |
| DW | 0.545 | 0.744 | 0.372 | -0.073 | 0.011 |
| DH | 0.106 | -0.028 | 0.992 | 0.061 | -0.012 |
| $DA_b$ | 0.846 | 0.370 | 0.373 | -0.003 | -0.004 |
| $DL_{ll}$ | 0.911 | -0.159 | 0.286 | -0.247 | 0.015 |
| $DL_{sl}$ | 0.838 | 0.043 | 0.216 | 0.498 | -0.041 |
| DO | 0.036 | -0.106 | 0.023 | 0.117 | 0.986 |
| $DS_l$ | -0.430 | -0.736 | 0.504 | 0.123 | -0.021 |
| $DS_{ll}$ | -0.803 | 0.133 | 0.502 | 0.288 | -0.024 |
| $DS_{sl}$ | -0.686 | -0.062 | 0.597 | -0.409 | 0.028 |
| DCR | -0.445 | 0.853 | 0.049 | 0.021 | 0.094 |
| K | 0.445 | -0.875 | -0.093 | 0.057 | -0.001 |
| L/W | 0.441 | -0.881 | -0.091 | 0.103 | -0.016 |
| L/H | 0.815 | -0.070 | -0.574 | -0.028 | 0.007 |
| W/H | 0.430 | 0.736 | -0.504 | -0.123 | 0.021 |
| L/S | -0.178 | 0.264 | -0.113 | 0.938 | -0.070 |
| DV | 0.693 | 0.266 | 0.670 | 0.003 | -0.002 |

| PC | Eigenvalues | % of Variance | Cumulative % |
|---|---|---|---|
| 1 | 6.720 | 39.527 | 39.527 |
| 2 | 4.259 | 25.054 | 64.581 |
| 3 | 3.396 | 19.975 | 84.556 |
| 4 | 1.508 | 8.872 | 93.428 |
| 5 | 0.991 | 5.831 | 99.259 |
| 6 | 0.082 | 0.485 | 99.744 |
| 7 | 0.042 | 0.248 | 99.992 |
| 8 | 1.43E-03 | 8.42E-03 | 100.00 |
| 9 | 8.95E-16 | 5.26E-15 | 100.00 |
| 10 | 7.28E-16 | 4.28E-15 | 100.00 |
| 11 | 3.97E-16 | 2.33E-15 | 100.00 |
| 12 | 2.66E-16 | 1.57E-15 | 100.00 |
| 13 | 1.05E-16 | 6.17E-16 | 100.00 |
| 14 | -2.70E-16 | -1.59E-15 | 100.00 |
| 15 | -5.94E-16 | -3.50E-15 | 100.00 |
| 16 | -1.29E-15 | -7.60E-15 | 100.00 |
| 17 | -1.43E-15 | -8.38E-15 | 100.00 |

All vriables were base-10 logarithmically transformed prior to analysis

Table 14. Tobacco Plains/Stillwater Valley Principal Component Table Definition #1.

**Principal Component Loadings**

| | PC 1 | PC 2 | PC 3 | PC 4 | PC 5 |
|---|---|---|---|---|---|
| DL | 0.960 | 0.195 | 0.122 | 0.000 | 0.136 |
| DW | 0.776 | -0.521 | 0.262 | -0.123 | 0.086 |
| DH | 0.378 | -0.338 | -0.752 | -0.117 | 0.348 |
| $DA_b$ | 0.922 | -0.067 | 0.238 | -0.075 | 0.239 |
| $DL_{II}$ | 0.906 | 0.288 | 0.086 | -0.228 | 0.102 |
| $DL_{sl}$ | 0.872 | -0.001 | 0.161 | 0.392 | 0.169 |
| DO | -0.528 | 0.436 | 0.636 | -0.004 | 0.178 |
| $DS_I$ | -0.418 | 0.243 | -0.822 | 0.036 | 0.215 |
| $DS_{II}$ | -0.836 | 0.128 | 0.273 | 0.042 | 0.375 |
| $DS_{sl}$ | -0.779 | 0.339 | 0.233 | -0.257 | 0.289 |
| DCR | -0.539 | -0.739 | 0.140 | -0.119 | 0.124 |
| K | 0.515 | 0.817 | -0.080 | 0.164 | -0.059 |
| L/W | 0.522 | 0.808 | -0.104 | 0.192 | -0.031 |
| L/H | 0.957 | 0.014 | 0.025 | 0.003 | -0.108 |
| W/H | 0.748 | -0.565 | 0.089 | -0.094 | -0.213 |
| L/S | -0.166 | -0.492 | 0.074 | 0.829 | 0.166 |
| DV | 0.907 | -0.070 | 0.022 | -0.134 | 0.371 |

| PC | Eigenvalues | % of Variance | Cumulative % |
|---|---|---|---|
| 1 | 9.008 | 52.988 | 52.988 |
| 2 | 3.325 | 19.556 | 72.544 |
| 3 | 2.001 | 11.770 | 84.314 |
| 4 | 1.102 | 6.480 | 90.794 |
| 5 | 0.787 | 4.630 | 95.424 |
| 6 | 0.288 | 1.694 | 97.118 |
| 7 | 0.164 | 0.962 | 98.080 |
| 8 | 9.12E-02 | 0.536 | 98.617 |
| 9 | 7.03E-02 | 0.413 | 99.030 |
| 10 | 5.73E-02 | 0.337 | 99.367 |
| 11 | 4.46E-02 | 0.262 | 99.629 |
| 12 | 2.44E-02 | 0.143 | 99.773 |
| 13 | 1.55E-02 | 9.11E-02 | 99.864 |
| 14 | 1.49E-02 | 8.74E-02 | 99.951 |
| 15 | 4.67E-03 | 2.75E-02 | 99.979 |
| 16 | 3.63E-03 | 2.13E-02 | 100 |
| 17 | 4.98E-12 | 2.93E-11 | 100 |

All metrics were base-10 logarithmically transformed prior to analysis

Table 15. Seeley/Swan Valley Principal Component Table Definition #2.

**Principal Component Loadings**

| | PC 1 | PC 2 | PC 3 | PC 4 | PC 5 |
|---|---|---|---|---|---|
| DL | 0.991 | -0.011 | 0.037 | 0.059 | 0.022 |
| DW | 0.607 | 0.764 | -0.069 | -0.058 | -0.020 |
| DH | 0.455 | 0.406 | 0.763 | 0.082 | 0.008 |
| $DA_b$ | 0.858 | 0.476 | 0.012 | 0.056 | 0.015 |
| $DL_{II}$ | 0.956 | -0.073 | 0.116 | -0.210 | 0.043 |
| $DL_{sl}$ | 0.837 | 0.094 | -0.103 | 0.493 | -0.018 |
| DO | -0.047 | -0.067 | -0.044 | 0.096 | 0.989 |
| $DS_I$ | -0.075 | -0.333 | 0.900 | 0.138 | -0.034 |
| $DS_{II}$ | -0.463 | 0.383 | 0.709 | 0.250 | -0.037 |
| $DS_{sl}$ | -0.231 | 0.293 | 0.839 | -0.317 | 0.041 |
| DCR | -0.461 | 0.796 | -0.164 | -0.047 | 0.092 |
| K | 0.409 | -0.876 | 0.111 | 0.032 | 0.022 |
| L/W | 0.404 | -0.879 | 0.121 | 0.075 | 0.006 |
| L/H | 0.701 | -0.129 | -0.341 | -0.107 | -0.058 |
| W/H | 0.071 | 0.368 | -0.852 | -0.158 | -0.009 |
| L/S | -0.305 | 0.142 | -0.259 | 0.896 | -0.067 |
| DV | 0.717 | 0.489 | 0.362 | 0.042 | 0.050 |

| PC | Eigenvalues | % of Variance | Cumulative % |
|---|---|---|---|
| 1 | 5.831 | 34.297 | 34.297 |
| 2 | 3.922 | 23.071 | 57.368 |
| 3 | 3.724 | 21.903 | 79.271 |
| 4 | 1.346 | 7.916 | 87.188 |
| 5 | 1.005 | 5.912 | 93.100 |
| 6 | 0.515 | 3.031 | 96.131 |
| 7 | 0.169 | 0.993 | 97.123 |
| 8 | 0.149 | 0.878 | 98.001 |
| 9 | 8.31E-02 | 0.489 | 98.490 |
| 10 | 7.28E-02 | 0.428 | 98.918 |
| 11 | 6.31E-02 | 0.371 | 99.289 |
| 12 | 4.96E-02 | 0.292 | 99.581 |
| 13 | 3.71E-02 | 0.218 | 99.799 |
| 14 | 1.78E-02 | 0.105 | 99.904 |
| 15 | 1.28E-02 | 7.53E-02 | 99.979 |
| 16 | 3.50E-03 | 2.06E-02 | 100 |
| 17 | 9.64E-12 | 5.67E-11 | 100 |

All vriables were base-10 logarithmically transformed prior to analysis

Table 16. Tobacco Plains/Stillwater Valley Principal Component Table Definition #2.

**Principal Component Loadings**

| | PC 1 | PC 2 | PC 3 | PC 4 | PC 5 |
|---|---|---|---|---|---|
| DL | 0.971 | 0.113 | 0.199 | 0.006 | 0.053 |
| DW | 0.575 | -0.651 | 0.483 | -0.085 | 0.002 |
| DH | 0.091 | 0.276 | 0.954 | 0.042 | 0.062 |
| $DA_b$ | 0.882 | -0.267 | 0.375 | -0.021 | 0.035 |
| $DL_{ll}$ | 0.937 | 0.177 | 0.187 | -0.235 | 0.013 |
| $DL_{sl}$ | 0.863 | -0.027 | 0.192 | 0.454 | 0.108 |
| DO | -0.223 | -0.060 | -0.139 | -0.220 | 0.937 |
| $DS_l$ | -0.463 | 0.822 | 0.302 | 0.112 | 0.047 |
| $DS_{ll}$ | -0.873 | -0.003 | 0.409 | 0.260 | 0.026 |
| $DS_{sl}$ | -0.763 | 0.210 | 0.452 | -0.405 | -0.062 |
| DCR | -0.582 | -0.741 | 0.157 | -0.033 | 0.091 |
| K | 0.601 | 0.745 | -0.231 | 0.052 | 0.057 |
| L/W | 0.589 | 0.760 | -0.231 | 0.089 | 0.061 |
| L/H | 0.888 | -0.076 | -0.452 | -0.022 | 0.010 |
| W/H | 0.463 | -0.822 | -0.302 | -0.112 | -0.047 |
| L/S | -0.230 | -0.288 | -0.020 | 0.921 | 0.121 |
| DV | 0.761 | -0.116 | 0.635 | -0.017 | 0.049 |

| PC | Eigenvalues | % of Variance | Cumulative % |
|---|---|---|---|
| 1 | 7.972 | 46.891 | 46.891 |
| 2 | 3.799 | 22.346 | 69.238 |
| 3 | 2.708 | 15.929 | 85.167 |
| 4 | 1.437 | 8.452 | 93.619 |
| 5 | 0.938 | 5.520 | 99.139 |
| 6 | 0.104 | 0.612 | 99.751 |
| 7 | 4.07E-02 | 0.239 | 99.990 |
| 8 | 1.71E-03 | 1.01E-02 | 100 |
| 9 | 1.92E-15 | 1.13E-14 | 100 |
| 10 | 1.36E-15 | 7.97E-15 | 100 |
| 11 | 4.02E-16 | 2.37E-15 | 100 |
| 12 | 1.60E-16 | 9.42E-16 | 100 |
| 13 | -9.87E-17 | -5.81E-16 | 100 |
| 14 | -3.72E-16 | -2.19E-15 | 100 |
| 15 | -6.66E-16 | -3.92E-15 | 100 |
| 16 | -1.04E-15 | -6.13E-15 | 100 |
| 17 | -1.38E-15 | -8.10E-15 | 100 |

All metrics were base-10 logarithmically transformed prior to analysis

Table 17. Principal Component Table - Seeley & Tobacco Data Combined Def. #1.

**Principal Component Loadings**

| | PC 1 | PC 2 | PC 3 | PC 4 | PC 5 |
|---|---|---|---|---|---|
| DL | 0.948 | -0.105 | 0.183 | -0.134 | 0.187 |
| DW | 0.657 | 0.672 | 0.267 | -0.171 | 0.092 |
| DH | 0.388 | 0.144 | 0.865 | 0.230 | -0.122 |
| $DA_b$ | 0.891 | 0.298 | 0.251 | -0.146 | 0.159 |
| $DL_{ll}$ | 0.947 | -0.094 | 0.216 | -0.152 | -0.059 |
| $DL_{sl}$ | 0.883 | 0.038 | 0.076 | 0.193 | 0.416 |
| DO | -0.558 | -0.114 | -0.053 | -0.535 | 0.574 |
| $DS_l$ | -0.276 | -0.543 | 0.617 | 0.413 | -0.220 |
| $DS_{ll}$ | -0.865 | 0.139 | 0.385 | 0.113 | 0.251 |
| $DS_{sl}$ | -0.784 | -0.042 | 0.530 | -0.306 | -0.038 |
| DCR | -0.497 | 0.804 | 0.000 | -0.026 | -0.014 |
| K | 0.454 | -0.866 | -0.074 | -0.024 | 0.123 |
| L/W | 0.454 | -0.870 | -0.066 | 0.021 | 0.131 |
| L/H | 0.868 | -0.075 | -0.456 | 0.045 | -0.148 |
| W/H | 0.627 | 0.561 | -0.458 | 0.035 | -0.261 |
| L/S | -0.159 | 0.320 | -0.248 | 0.739 | 0.513 |
| DV | 0.811 | 0.267 | 0.513 | -0.035 | 0.069 |

| PC | Eigenvalues | % of Variance | Cumulative % |
|---|---|---|---|
| 1 | 8.193 | 48.192 | 48.192 |
| 2 | 3.558 | 20.932 | 69.125 |
| 3 | 2.533 | 14.897 | 84.022 |
| 4 | 1.297 | 7.627 | 91.649 |
| 5 | 1.094 | 6.432 | 98.082 |
| 6 | 0.176 | 1.035 | 99.116 |
| 7 | 9.40E-02 | 0.553 | 99.669 |
| 8 | 3.70E-02 | 0.218 | 99.887 |
| 9 | 1.83E-02 | 0.108 | 99.995 |
| 10 | 9.19E-04 | 5.41E-03 | 100 |
| 11 | 4.11E-12 | 2.42E-11 | 100 |
| 12 | 2.15E-12 | 1.26E-11 | 100 |
| 13 | 1.33E-12 | 7.79E-12 | 100 |
| 14 | 9.79E-16 | 5.76E-15 | 100 |
| 15 | 5.30E-16 | 3.12E-15 | 100 |
| 16 | -3.26E-16 | -1.92E-15 | 100 |
| 17 | -6.63E-16 | -3.90E-15 | 100 |

All vriables were base-10 logarithmically transformed prior to analysis

Table 18. Principal Component Table - Seeley & Tobacco Data Combined Def. #2.

**PCA Comparison of the Two Delineation Definitions** – The comparison of the two PCA drumlin definition results are shown in Tables 17 and 18. The metrics that represented the highest loadings for each principal component were *DL*, $DS_l$, *DH*, *L/S*, and *DO* for definition #1 and *DL*, *L/W*, *DH*, *L/S*, and *DO* for definition #2. As a result they are considered to be the most descriptive metrics for each definition. As can be seen the metrics representing the highest loadings for each principal component were the same for both definitions with the exception of principal component number two. However, the metric with the second highest loading or weight for principal component two in definition #1 matches the metric with the highest loading for definition #2. As a result, the most descriptive metrics for Montana drumlins are *DL*, *L/W*, *DH*, *L/S*, and *DO*.

**Drumlin Field Statistics**

Drumlin field statistics were compiled for each field, which encompassed all of the drumlins in that given area. The drumlin field boundary remained the same for both drumlin delineation definitions. The values for the two Montana drumlin fields are shown in Tables19 and 20. These descriptive statistics showed that the Tobacco field was longer, wider, greater in area, and had a greater number of drumlins than the Seeley/Swan field. The Seeley/Swan field had more drumlin twins and was more compact. Drumlin density ($F_dD$ per km$^2$) showed a difference between the two fields for both definitions; however, the differences were not extreme. For both definitions the Seeley/Swan field had a greater density than the Tobacco field. This is, most likely, due to the fact that the Seeley/Swan field covers only half of the area that the Tobacco field does.

| | Seeley Field | Tobacco Field |
|---|---|---|
| FL (m) | 34,052.2 | 40,214.1 |
| FW (m) | 6,810.8 | 8,698.4 |
| FA ($m^2$) | 107,926,074.3 | 221,559,144.5 |
| $F_dN$ | 96 | 147 |
| $F_dT$ | 10 | 7 |
| $F_dP$ | 0.07 | 0.07 |
| $F_dD$ (per $km^2$) | 0.89 | 0.66 |
| FCR | 0.32 | 0.36 |

Table 19. Montana Drumlin Field Metrics Definition #1.

| | Seeley Field | Tobacco Field |
|---|---|---|
| FL (m) | 34,052.2 | 40,214.1 |
| FW (m) | 6,810.8 | 8,698.4 |
| FA ($m^2$) | 107,926,074.3 | 221,559,144.5 |
| $F_dN$ | 121 | 175 |
| $F_dT$ | 10 | 7 |
| $F_dP$ | 0.08 | 0.07 |
| $F_dD$ (per $km^2$) | 1.21 | 0.79 |
| FCR | 0.32 | 0.36 |

Table 20. Montana Drumlin Field Metrics Definition #2.

**Drumlin Delineation Definition Comparison** - Only the number of drumlins and drumlin distribution differed between the two different drumlin delineation definitions. The percent area drumlins ($F_dP$) differed by only 1 % between the drumlin delineation definitions in the Seeley/Swan field. There was no change between definitions for the Tobacco field. The average drumlin density per square kilometer ($F_dD$ per $km^2$) showed only marginal change between definitions for both Montana fields.

**Nearest-Neighbor Analysis (NNA)**

**NNA Using Drumlin Delineation Definition #1** - The results of the nearest-neighbor analysis for definition #1 are presented in Table 20. The *NNI* was greater than 1.0 for both of the drumlin fields with the Seeley/Swan *NNI* at 1.26 and the Tobacco *NNI* at 1.06. Drumlin distributions were similar. Since the *NNI*s were greater than 1, both fields are considered "dispersed."

**NNA Using Drumlin Delineation Using Definition #2 -** The results of the nearest-neighbor analysis for definition #2 are presented in Table 22. The *NNI* was greater than one for both of the drumlin fields with the Seeley/Swan *NNI* at 1.35 and the Tobacco *NNI* at 1.04. This showed that drumlin distribution was similar. Since the *NNI*s were greater than 1, both fields are considered "dispersed."

**NNA Comparison of the Two Delineation Definitions –** The *NNI* differed by only 0.09 between the two delineation definitions for the Seeley/Swan field, a very small difference. For the Tobacco field the *NNI* differed by only 0.02, which was even smaller than for the Seeley/Swan field. As a result, the two definitions generated nearest-neighbor analysis results that are virtually the same for the two fields, showing that drumlin delineation definitions had little effect on nearest-neighbor analysis.

| | Seeley Field | Tobacco Field |
|---|---|---|
| NN Index (*NNI*) | 1.26 | 1.06 |
| Ave. Dist. (m)($D_{obs}$) | 666.47 | 648.40 |
| Exp. Ave. Dist. (m)($D_{exp}$) | 530.15 | 613.84 |
| Polygon Area ($m^2$) (*A*) | 107,926,074.3 | 221,559,144.5 |
| Standard Deviation (*SD*) | 28.28 | 26.46 |
| Standard z-value (*Z*) | 4.82 | 1.31 |
| Number of Pts. | 96 | 147 |

Table 21. Nearest-Neighbor Analysis Definition #1.

| | Seeley Field | Tobacco Field |
|---|---|---|
| NN Index (*NNI*) | 1.35 | 1.04 |
| Ave. Dist. (m) ($D_{obs}$) | 636.77 | 587.29 |
| Exp. Ave. Dist. (m) ($D_{exp}$) | 472.22 | 526.59 |
| Polygon Area ($m^2$) (*A*) | 107,926,074.3 | 221,559,144.5 |
| Standard Deviation (*SD*) | 22.44 | 22.23 |
| Standard z-value (*Z*) | 7.33 | 1.11 |
| Number of Pts. | 121 | 175 |

Table 22. Nearest-Neighbor Analysis Definition #2.

**Drumlin Density Maps**

In the Seeley/Swan field, there seemed to be three comparatively dense locations, in the northern, middle, and southern third of the map (Appendix M). In the Tobacco field the drumlin distribution got denser in the middle third of the field. Furthermore, the density seemed to be more evenly distributed in the Tobacco field (Appendix M). The difference between the two drumlin delineation definitions had little affect on drumlin density and had no real change in the density patterns shown on the maps (Appendix M).

# CHAPTER 5

# DISCUSSION

## Possible Form Variables

There is still no consensus on the processes and conditions required for drumlin formation. Furthermore, the causes of drumlin form variations are disputed. Nonetheless, many researchers have speculated on the shaping of drumlins. The greatest emphasis has been placed on drumlin elongation factors.

### Elongation Factors

Two dominant elongation factors examined are glaciological and geological factors.

***Glaciological Factors*** – Glaciological factors speculated to affect drumlin elongation include ice thickness, ice velocity, and consistent direction of ice flow.

*Ice Thickness and Ice Velocity* – Ice thickness and ice velocity are directly related to each other (Embleton and King 1969, 336). It has been proposed that ice flow velocity relates to drumlin elongation (Charlesworth 1957, 394; Crozier 1975, 185; Embleton and King 1969, 324-326). Where ice flow was sluggish drumlins were relatively blunt and where ice moved rapidly drumlins elongated. Embleton and King (1969, 336) found in their study that elongation increased in the Tyne gap where ice was forced to accelerate.

Thicker and higher velocity ice is thought to create more elongated drumlins (Embleton and King 1969, 336).

The hypothesis regarding ice thickness and velocity appears to apply in Montana since the thickness of the Flathead lobe of the Cordilleran ice sheet may have exceeded 4,000 feet at the Montana-Canadian border (Johns 1970, 7) whereas the Swan Valley glacier thickness was probably around 2,000 feet. The Flathead lobe velocities were undoubtedly greater owing to its appreciably greater thickness.

Ice thickness and velocity differences may account for the differences between the Seeley/Swan drumlins and the Tobacco drumlins. The Tobacco drumlins were more elongated than the Seeley/Swan drumlins, possibly the result of thicker and faster ice.

*Local Flow Direction Consistency* – Another glaciological factor thought to have an effect on drumlin elongation is consistency of local ice flow direction (Doornkamp and King 1971, 302; Embleton and King 1969, 325; Jauhiainen 1975, 226). Under this hypothesis drumlins are more elongated where ice flow experiences fewer direction changes. The evidence used to support this has been based on findings that drumlin elongation increases where the standard deviation of drumlin orientation decreases.

The directional consistency of flow hypothesis may explain the difference in elongation between the two Montana fields. The Seeley/Swan field had a *DO* standard deviation ($\sigma$) of $\pm 13.62$ and the drumlins were less elongated. The Tobacco drumlins had a standard deviation ($\sigma$) of $\pm 10.87$ and were more elongated. Thus, local flow direction in the Tobacco study area showed greater consistency.

One hypothesis used to explain the greater flow direction variability in the Seeley/Swan Valley stems from a somewhat unusual spatial pattern of its drumlins

(Figure 4). No drumlin occurs within the three ovals shown on the map. Arrows east of the ovals indicate where former alpine ice streams fed into the Seeley/Swan Valley. The entrance of these tributaries into the trunk ice might have disturbed the main direction of flow, which was recorded by slight changes in drumlin alignment. In contrast, the Tobacco drumlin field showed no evidence of former alpine ice mergers with the main glacier. Whether that was simply because the low, surrounding mountains generated insignificant or no tributary ice or because the Flathead Lobe was too thick to be sufficiently disturbed is unknown. As a result, this hypothesis could not be ruled out as a factor in the greater drumlin elongation values of the Tobacco field in contrast to the Seeley/Swan field.

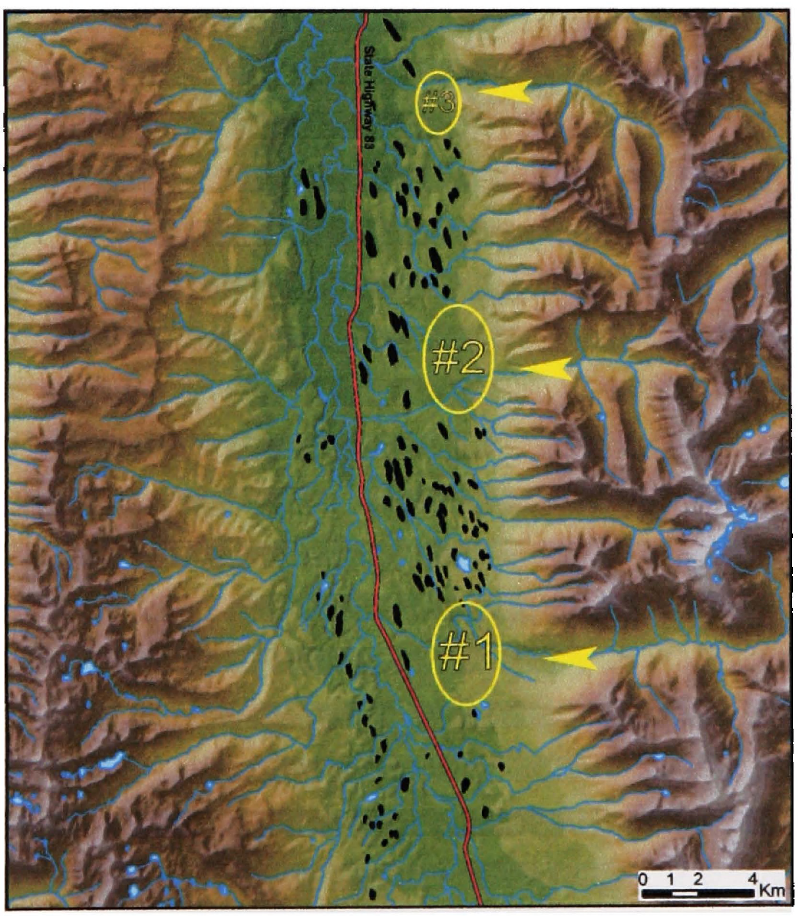



Figure 4. Lateral Alpine Ice Feed Seeley/Swan Valley.

***Geological Factors*** – Geological factors considered to be possible controls of drumlin elongation include drift thickness, till texture, local ground relief or slope, and bedrock lithology.

*Drift Thickness* – Some researchers observed that drumlins tend to be more elongated where drift is thinner (Charlesworth 1957, 399; Heidenreich 1964, 105). In contrast, other researchers have observed no such relationship between elongation and drift depth (Crozier 1975, 187; Trenhaile 1975, 312). Furthermore, there might be a critical depth, below which drift thickness does not matter since the depth of till deformed by moving ice does not extend down very far.

I compared drift thickness for the Montana fields using a combination of geological maps and reports (Jones 1996; Mudge et al. 1982; Witkind 1995). Geological maps showed cross-sections of drift depths for the Tobacco Plains and gave text descriptions of tabled attributes. I determined that the Seeley/Swan drift depths ranged from about 100 to 300 meters and the Tobacco drift depths averaged about 100 meters. Based on this, the Tobacco drumlins could have greater elongation because they developed in thinner drift. However, since Crozier (1975) and Trenhaile (1975) discovered no relationship between elongation and drift depth this is an unlikely cause for differences between the Montana fields.

*Till Texture* – I also compared till texture, or particle-size composition, between the two Montana fields. However, because the texture for the two fields was so similar no determinations regarding this factor were made.

*Local Relief/Slope* – One control of glacial flow velocities is the slope of the underlying ground surface. Ice descending a steeper slope would increase its velocity

and probably increase drumlin elongation. Also, Aronow (1959, 201) and Trenhaile (1975, 312) found that drumlins were blunter where glacial ice flowed upslope. My results, however, do not support these findings. Tobacco drumlins were more elongated, yet, based on stream flow direction, they developed on a gentle upward surface gradient. Conversely, the blunter Seeley/Swan drumlins formed on a gentle down-slope gradient, according to stream flow direction. Perhaps the Tobacco drumlins formed under such a powerful ice flow that the gentle upward gradient simply had little or no effect.

*Lithology* – Mills (1980, 2276) suggested that bedrock lithology might play a role in drumlin elongation. He found that more elongated drumlins tended to occur in areas underlain by sedimentary rock and less elongated drumlins tended to be underlain by igneous or metamorphic rocks. He presumed that this correlation resulted from the different erosibilities of the bedrock. Although the drumlin fields in Montana rest on thick glacial till, the underlying bedrock is sedimentary (Johns 1970; Mudge et al. 1982; Witkind 1978; Witkind and Weber 1982). Since the two Montana fields are underlain by similar sedimentary bedrock this possible elongation factor appears inapplicable. Furthermore, if there is a shallow critical depth, below which ice had no effect, then bedrock lithology wouldn't matter either.

***Conclusions*** – In regard to factors that may influence Montana drumlin elongation, it seems that glaciological influences outweigh geological. Therefore, the significant differences between the two fields are most likely due to differences in either ice thickness, ice velocity, directional flow consistency, or a combination of those glaciological factors.

### Potential Factors That Influence Other Form Variables

Little research has examined how geological and glaciological factors have influenced form variables other than elongation (i.e. $DL$, $DW$, $DH$, $DA_b$, etc.).

***Geological Factors*** – Geological factors considered to be possible controls of other metrics include drift thickness, till texture, and bedrock lithology.

*Drift Thickness* – Drift thickness is one potential factor for differences among drumlin metrics other than elongation. Drift thickness may have affected other form variables since the Tobacco drumlins were formed in a shallower layer of drift than the Seeley/Swan drumlins. However, if there is a critical depth, below which ice had no effect, drift thickness would be irrelevant.

*Till Texture* – Due to the similar till texture between the two Montana fields, no determinations regarding this factor were made.

*Lithology* – Since the two Montana fields are underlain by similar sedimentary bedrock this possible elongation factor appears inapplicable. Furthermore, if there is a shallow critical depth, below which ice had no effect, then bedrock lithology wouldn't matter either.

***Glaciological Factors*** – Due to the similar geological settings of the Montana fields the cause for the differences most likely comes from glaciological processes. Thus, ice thickness, ice velocity, and consistent direction of ice flow are the more likely cause of differences among other form variables.

***Conclusions*** – In the Montana settings significant metric differences between the drumlin fields were, most likely, due to glaciological differences rather than

to geological. Geological factors were eliminated because of the similarities between the Montana fields.

## General Inferences

The potential ice flow factors hypothesized in other studies to control drumlin elongation seem to apply to the two Montana drumlin fields more strongly than geological factors. The lack of conclusive findings for geological factors points to the glaciological factors to explain differences in the metrics. The Seeley/Swan field had smaller metric values than the Tobacco field. This shows that Seeley/Swan drumlins are smaller than Tobacco drumlins and leads to the inference that thinner and possibly slower ice produced smaller drumlin values, while thicker and possibly faster ice produced larger drumlin values.

## Comparisons between Montana and Literature Data

### Metrics Used for Comparison

The most common metrics included in the drumlin literature were length, width, height, and length/width ratio (elongation). Most of the literature listed only the mean values for these metrics; however, I did find four studies that reported both mean values and standard deviations for the common metrics. Three of the four studies reported only a small number of metrics such as length, width, height, and length/width ratio. For this reason I chose to use the one remaining study done by Mills (1980), which incorporated the largest number of metrics against which to compare mine. Furthermore, Mills reported both their means and standard deviations. Additionally, the Mills study used similar, and in most cases identical, techniques to collect the data. It included 17 drumlin

fields within the states of Connecticut, Massachusetts, New York, Michigan, Wisconsin, and Minnesota (Figure 5).


Figure 5. Drumlin Field Locations Used in the Mills Study.

The metrics used by Mills and me were length (*DL*), width (*DW*), height (*DH*), length/width ratio (*L/W*), length/height ratio (*L/H*), width/height ratio (*W/H*), long link slope ($DS_{ll}$), short link slope ($DS_{sl}$), and long link slope/short link slope ratio (*L/S*).

The Montana data used for this literature comparison were derived from drumlins portrayed on quadrangles with 20-foot contour intervals. This was done so that drumlin delineation was the same as was done in the literature. In the Seeley/Swan field two out of the five quadrangles had 20-foot contour intervals and in the Tobacco field three out of eight quadrangles had 20-foot contour intervals. However, despite fewer quadrangles, the number of drumlins was still large enough to provide a good comparison with the literature data (Seeley: 106 out of a total 121 drumlins; Tobacco: 151 out of a total 175

drumlins). The means and standard deviations of the two Montana fields are shown in Table 21, which also presents the Mills data.

### Frequency Distribution Results

Mills reported that all metrics were skewed and became normally distributed only after logarithmic transformations. The Seeley/Swan drumlins displayed normal distributions for *DH* and *DO*. All other metrics were normally distributed only after a logarithmic transformation much like the data reported in the literature. These same findings were also true for the Tobacco field.

### Literature Comparison Descriptive Statistics

Mills' data are shown in Table 23. No difference of means test was used in this comparison because there were only two Montana drumlin fields.

The comparison of the Montana and literature data showed that both the Seeley/Swan drumlins and Tobacco drumlins were below average in *DL*, *DW*, *L/H*, *W/H*, and *L/S*, and above average in *DH*, *L/W*, $DS_{sl}$, and $DS_{ll}$. Montana *DW* and *W/H* metric values were below the literature minimum values and *L/H* for the Seeley/Swan was below the minimum while the Tobacco drumlins were barely above the minimum value. Perhaps the confined nature of narrow mountain valleys in contrast to open plains is the cause of Montana drumlins having these below minimum values.

### Literature Comparison of Pearson's Correlation Coefficients

The Mills study produced five correlation matrices from the 17 drumlin fields (Appendix L). Montana correlation matrices were created for the literature comparison using the same metrics as those used in the Mills study (Tables 24 and 25). In the Mills study, it was found that *DH* tended to have a stronger correlation with *DW* than with *DL*.

| Drumlin Field | Test | DL | DW | DH | L/W | L/H | W/H | $DS_{al}$ | $DS_{l}$ | L/S |
|---|---|---|---|---|---|---|---|---|---|---|
| N.E. Connecticut | Average | 729.00 | 311.00 | 17.20 | 2.44 | 50.40 | 20.50 | 0.056 | 0.057 | 1.12 |
| | STDEV | 262.00 | 99.00 | 8.00 | 0.86 | 28.50 | 7.70 | 0.027 | 0.029 | 0.49 |
| Worcester, Mass. | Average | 537.00 | 262.00 | 17.50 | 2.11 | 32.80 | 15.80 | 0.074 | 0.068 | 0.97 |
| | STDEV | 210.00 | 96.00 | 7.70 | 0.57 | 10.30 | 4.40 | 0.026 | 0.025 | 0.38 |
| Boston, Mass. | Average | 544.00 | 323.00 | 15.10 | 1.79 | 40.10 | 23.40 | 0.059 | 0.063 | 1.21 |
| | STDEV | 188.00 | 141.00 | 8.10 | 0.45 | 15.20 | 9.40 | 0.027 | 0.037 | 0.66 |
| Northeast Mass. | Average | 606.00 | 306.00 | 20.40 | 2.02 | 31.90 | 16.00 | 0.083 | 0.074 | 1.00 |
| | STDEV | 302.00 | 145.00 | 9.80 | 0.57 | 12.90 | 5.60 | 0.037 | 0.032 | 0.53 |
| Central-West New York | Average | 901.00 | 228.00 | 18.40 | 5.02 | 60.40 | 13.80 | 0.057 | 0.040 | 0.80 |
| | STDEV | 353.00 | 114.00 | 8.60 | 3.90 | 45.30 | 7.00 | 0.032 | 0.021 | 0.38 |
| Iron River Mich. | Average | 642.00 | 232.00 | 11.70 | 2.96 | 59.00 | 20.30 | 0.043 | 0.035 | 0.90 |
| | STDEV | 132.00 | 78.00 | 3.70 | 0.82 | 18.80 | 5.10 | 0.014 | 0.014 | 0.60 |
| Menominee, Mich. | Average | 1045.00 | 238.00 | 14.30 | 4.73 | 77.10 | 18.10 | 0.039 | 0.027 | 0.77 |
| | STDEV | 417.00 | 76.00 | 5.30 | 2.33 | 32.70 | 7.00 | 0.018 | 0.012 | 0.33 |
| Grand Traverse, Mich. | Average | 930.00 | 220.00 | 13.50 | 4.82 | 74.20 | 17.70 | 0.038 | 0.030 | 0.90 |
| | STDEV | 320.00 | 80.00 | 4.70 | 2.58 | 28.80 | 8.50 | 0.022 | 0.017 | 0.52 |
| Presque Isle, Mich. | Average | 1036.00 | 354.00 | 11.70 | 3.25 | 91.90 | 31.10 | 0.031 | 0.025 | 1.01 |
| | STDEV | 411.00 | 154.00 | 3.50 | 1.43 | 35.20 | 11.80 | 0.021 | 0.010 | 0.66 |
| Kalamazoo/Calhoun, Mich. | Average | 575.00 | 274.00 | 7.80 | 2.22 | 79.20 | 37.10 | 0.033 | 0.026 | 0.89 |
| | STDEV | 175.00 | 94.00 | 2.60 | 0.67 | 26.50 | 12.40 | 0.017 | 0.009 | 0.27 |
| Green Bay, Wis. | Average | 971.00 | 240.00 | 14.40 | 4.18 | 73.00 | 18.30 | 0.050 | 0.032 | 0.70 |
| | STDEV | 467.00 | 75.00 | 5.50 | 2.06 | 38.80 | 7.30 | 0.029 | 0.021 | 0.34 |
| Fond du Lac, Wis. | Average | 630.00 | 301.00 | 19.70 | 2.16 | 34.40 | 15.90 | 0.076 | 0.057 | 0.81 |
| | STDEV | 168.00 | 68.00 | 5.60 | 0.64 | 14.10 | 3.50 | 0.028 | 0.023 | 0.31 |
| Hartland/Genesee, Wis. | Average | 437.00 | 209.00 | 14.10 | 2.19 | 37.10 | 16.80 | 0.070 | 0.064 | 0.99 |
| | STDEV | 132.00 | 78.00 | 8.20 | 0.59 | 16.20 | 5.90 | 0.036 | 0.027 | 0.32 |
| Batavia/Random Lake, Wis. | Average | 558.00 | 323.00 | 15.00 | 1.78 | 42.30 | 23.30 | 0.065 | 0.053 | 0.94 |
| | STDEV | 145.00 | 85.00 | 5.90 | 0.47 | 19.10 | 7.10 | 0.031 | 0.020 | 0.48 |
| Wadena, Minn. | Average | 778.00 | 280.00 | 7.60 | 2.90 | 115.80 | 40.20 | 0.027 | 0.026 | 1.05 |
| | STDEV | 375.00 | 89.00 | 2.80 | 1.40 | 72.00 | 14.80 | 0.024 | 0.021 | 0.49 |
| Pierz, Minn. | Average | 962.00 | 330.00 | 5.90 | 3.04 | 171.20 | 57.10 | 0.016 | 0.014 | 1.03 |
| | STDEV | 449.00 | 130.00 | 2.00 | 1.22 | 78.20 | 19.60 | 0.008 | 0.007 | 0.47 |
| Toimi, Minn. | Average | 899.00 | 307.00 | 8.30 | 3.06 | 118.30 | 40.00 | 0.024 | 0.021 | 0.96 |
| | STDEV | 518.00 | 134.00 | 4.40 | 1.40 | 64.80 | 15.00 | 0.014 | 0.011 | 0.43 |
| Literature All | Average | 751.76 | 278.71 | 13.68 | 2.98 | 69.95 | 25.02 | 0.05 | 0.04 | 0.94 |
| Literature All | STDEV | 194.22 | 43.27 | 4.23 | 1.05 | 36.59 | 11.64 | 0.02 | 0.02 | 0.13 |
| Literature Data Range | Range | 608.00 | 145.00 | 14.50 | 3.24 | 139.30 | 43.30 | 0.067 | 0.060 | 0.51 |
| Seeley | Average | 515.63 | 171.40 | 14.70 | 3.04 | 29.53 | 9.88 | 0.120 | 0.080 | 0.72 |
| | STDEV | 229.87 | 56.32 | 4.02 | 0.95 | 15.69 | 4.46 | 0.090 | 0.060 | 0.18 |
| Tobacco | Average | 582.47 | 187.91 | 18.07 | 3.31 | 35.16 | 11.26 | 0.080 | 0.060 | 0.74 |
| | STDEV | 202.77 | 71.72 | 7.94 | 1.21 | 12.58 | 4.17 | 0.040 | 0.020 | 0.18 |
| Montana All | Average | 554.60 | 181.02 | 16.67 | 3.20 | 32.81 | 10.69 | 0.10 | 0.07 | 0.72 |
| | STDEV | 217.00 | 66.24 | 6.80 | 1.12 | 14.24 | 4.35 | 0.066 | 0.044 | 0.18 |

Only the drumlins contained on maps with 20' contours were used in the literature comparison
Minimum vlaues are highlighted in yellow
Maximum vlaues are highlighted in green

Table 23. Literature Comparison Data.

This was also true with both Montana fields; however, the differences were marginal. Mills also found that *DW and DL* correlation coefficients were similar to that of *DW and DH*. This was also true with the Seeley/Swan field but not for the Tobacco field. In addition, Mills found that *L/W and DL* were more strongly correlated than *L/W and DW*. I found this to be true for both of the Montana drumlin fields.

| | DL | DW | DH | L/W | L/H | W/H | $DS_{sl}$ | $DS_{ll}$ | L/S |
|---|---|---|---|---|---|---|---|---|---|
| DL | 1.00 | | | | | | | | |
| DW | 0.71 | 1.00 | | | | | | | |
| DH | 0.40 | 0.47 | 1.00 | | | | | | |
| L/W | 0.60 | -0.14 | 0.03 | 1.00 | | | | | |
| L/H | 0.89 | 0.75 | 0.55 | 0.41 | 1.00 | | | | |
| W/H | 0.63 | 0.89 | 0.58 | -0.13 | 0.86 | 1.00 | | | |
| $DS_{sl}$ | -0.82 | -0.75 | -0.53 | -0.30 | -0.95 | -0.86 | 1.00 | | |
| $DS_{ll}$ | -0.89 | -0.71 | -0.54 | -0.45 | -0.98 | -0.81 | 0.88 | 1.00 | |
| L/S | -0.20 | 0.04 | -0.04 | -0.33 | -0.14 | 0.04 | -0.19 | 0.31 | 1.00 |

All variables were logarithmically transformed (base 10) before analysis

Table 24. Seeley/Swan Valley Correlation Matrix for Literature Comparison.

| | DL | DW | DH | L/W | L/H | W/H | $DS_{sl}$ | $DS_{ll}$ | L/S |
|---|---|---|---|---|---|---|---|---|---|
| DL | 1.00 | | | | | | | | |
| DW | 0.61 | 1.00 | | | | | | | |
| DH | 0.54 | 0.55 | 1.00 | | | | | | |
| L/W | 0.37 | -0.51 | -0.06 | 1.00 | | | | | |
| L/H | 0.37 | -0.01 | -0.59 | 0.42 | 1.00 | | | | |
| W/H | 0.04 | 0.42 | -0.52 | -0.45 | 0.62 | 1.00 | | | |
| $DS_{sl}$ | -0.20 | 0.07 | 0.64 | -0.30 | -0.90 | -0.62 | 1.00 | | |
| $DS_{ll}$ | -0.44 | -0.03 | 0.49 | -0.44 | -0.96 | -0.56 | 0.75 | 1.00 | |
| L/S | -0.31 | -0.13 | -0.25 | -0.18 | -0.03 | 0.13 | -0.40 | 0.30 | 1.00 |

All variables were logarithmically transformed (base 10) before analysis

Table 25. Tobacco Plains/Stillwater Valley Correlation Matrix for Lit. Comparison.

In another study, Trenhaile (1975, 305) found a strong correlation ($\geq 0.70$) between *DL and DW*. This occurred also in one of Mills' fields; in addition, I found this true of both Montana fields.

**Drumlin Distribution**

***Drumlin Density*** – A study done by Jauhiainen (1975, 226) in northern Central Europe reported the average densities of 12 drumlin fields. The results ranged from 0.48 drumlins per $km^2$ to 2.61 drumlins per $km^2$. This range includes my findings of 1.14 drumlins per $km^2$ for the Seeley/Swan field and .82 drumlins per $km^2$ for the Tobacco field. It indicates that average valley drumlin densities are similar to plains drumlin densities.

***Drumlin Nearest-Neighbor*** – Jauhiainen (1975, 226) reported that *NNI*s ranged from 0.72 to 1.26 in northern Central Europe, values which imply random distributions. Smalley and Unwin (1968, 387) reported that *NNI*s ranged from 1.12 to 1.38, values which imply both random to dispersed distributions in Ireland. The *NNIs* for the Seeley/Swan and Tobacco fields (Table 26) were 1.33 and 1.04 respectively, which revealed findings similar to those reported in the literature. This suggests that drumlin location is random to dispersed even in confined areas. Perhaps randomness is connected to differences in longitudinal factors and not to width or pre-glacial factors.

**Nearest Neighbor Analysis and Density per km$^2$ Results**
**20' Contour Maps Only (for literature comparisons)**

| | Seeley Field | Tobacco Field |
|---|---|---|
| NN Index | 1.3300 | 1.0400 |
| Ave. Dist. (m) | 624.2400 | 574.8600 |
| Exp. Ave. Dist. (m) | 468.8900 | 553.1300 |
| Polygon Area (m$^2$) | 93,221,977.6 | 184,795,586.1 |
| Number of Pts. | 106 | 151 |
| Density per km$^2$ | 1.14 | 0.82 |

Table 26. Nearest-Neighbor Analysis and Density Results for Literature Comparison.

# CHAPTER 6

# CONCLUSIONS

## Data Distribution/Frequency Distributions

Drumlin metric frequency distributions are generally positively skewed with the exception of *DO*, *DW*, and *DCR*, and become normally distributed after logarithmic transformations.

## Morphometric Comparison

**Existence of Two Different Fields** – The Seeley/Swan Valley and Tobacco Plains/Stillwater Valley drumlins are morphometrically and morphologically different. The difference of means t-tests showed that all basic metrics were significantly different at the .05 level between the two drumlin fields for definition #1. Similarly, the t-test for definition #2 showed that all basic metrics and all but two of the total metrics were significantly different at the .05 level between the two drumlin fields. Given the similar geology for the two fields, I believe that the differences largely result from differing glaciological processes.

**Existence of Two Drumlin Delineation Definitions** – Drumlins portrayed by somewhat different contour intervals yield about the same morphometric data. The difference of means t-test showed that all but two of the basic metrics for the Seeley/Swan field and all but two of the total metrics for the Tobacco field were alike

under the two definitions. These statistics suggests that maps with slightly different contour intervals have little effect on the drumlin metrics.

## Principal Component Analysis (PCA)

**Existence of Principal Component Metrics for Definition #1 and #2 –** Drumlin metrics of length, elongation, height, lee slope/stoss slope ratio, and orientation best describe Montana drumlins and may best describe drumlins else where. The principal component metrics that best describe valley drumlins for definition #1 are *DL*, $DS_l$, *DH*, *L/S*, and *DO*. The principal component metrics that best describe valley drumlins for definition #2 are *DL*, *L/W*, *DH*, *L/S*, and *DO*. The only difference between definition #1 and #2 is principal component metric two. However, the metric with the second highest loading or weight for principal component two in definition #1 matches the metric with the highest loading for definition #2. As a result, the most descriptive metrics for Montana drumlins are *DL*, *L/W*, *DH*, *L/S*, and *DO*.

## Literature Comparison

Other than having narrower widths, in general, Montana drumlins cannot be morphometrically differentiated from plains drumlins. This implies that Montana drumlins were likely made by the same glaciological processes acting to about the same degree as in the formation of plains drumlins.

## Future Studies

To judge whether these conclusions are valid elsewhere, additional research is needed to describe the morphometry of a larger pool of valley drumlins.

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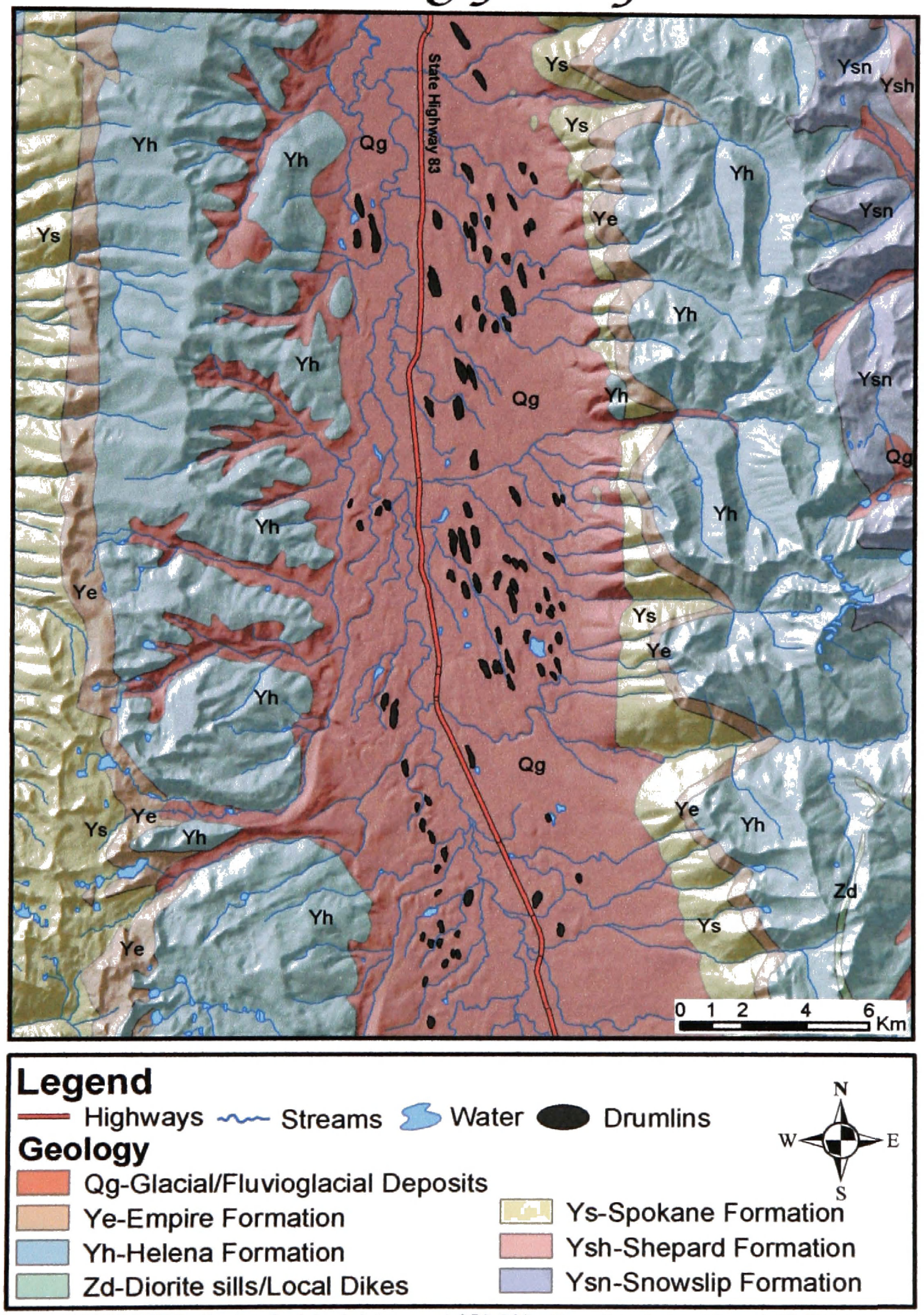
# APPENDIX A

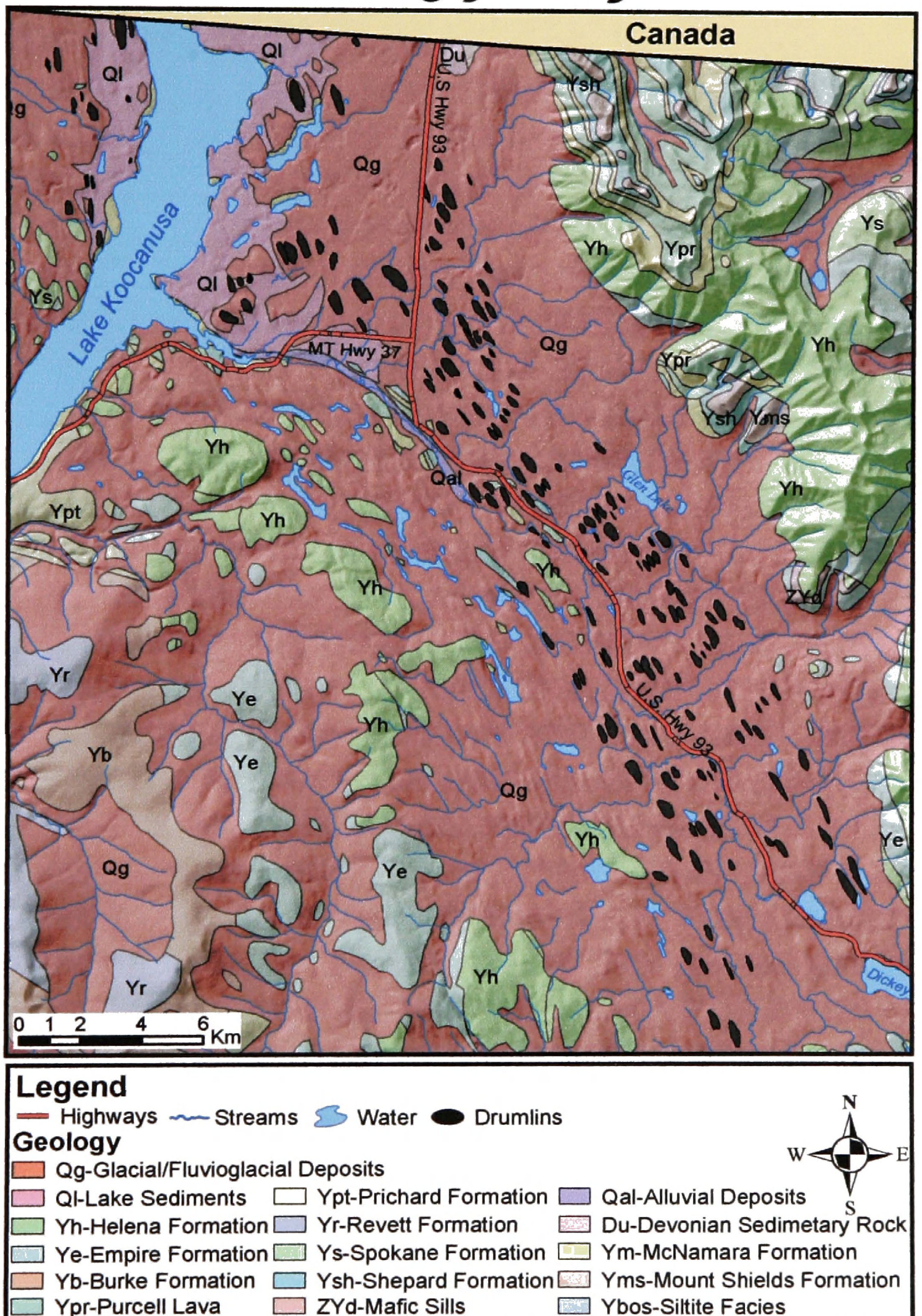
**Study Area Geology Maps**

# Seeley/Swan Valley Geology Map




Geology Source: USGS 2000 - Scale of original data was 1:250,000 - Drumlins derived from 1:25.000 topographic maps

# Tobacco Plains/Stillwater Valley Geology Map

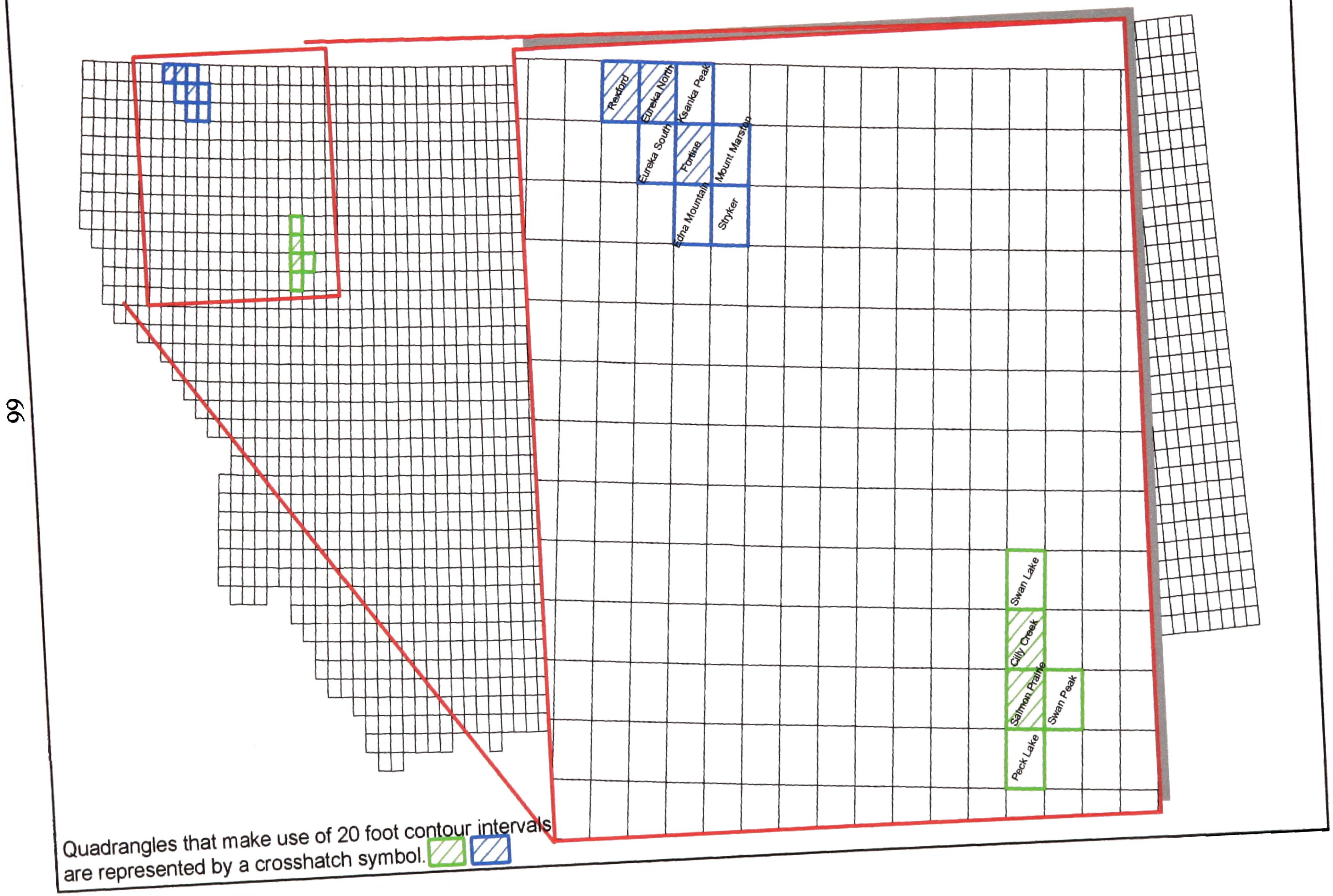



Geology Source: USGS 2000 - Scale of original data was 1:250,000 - Drumlins derived from 1:25.000 topographic maps

# APPENDIX B

**Study Area Quadrangle Index Map**

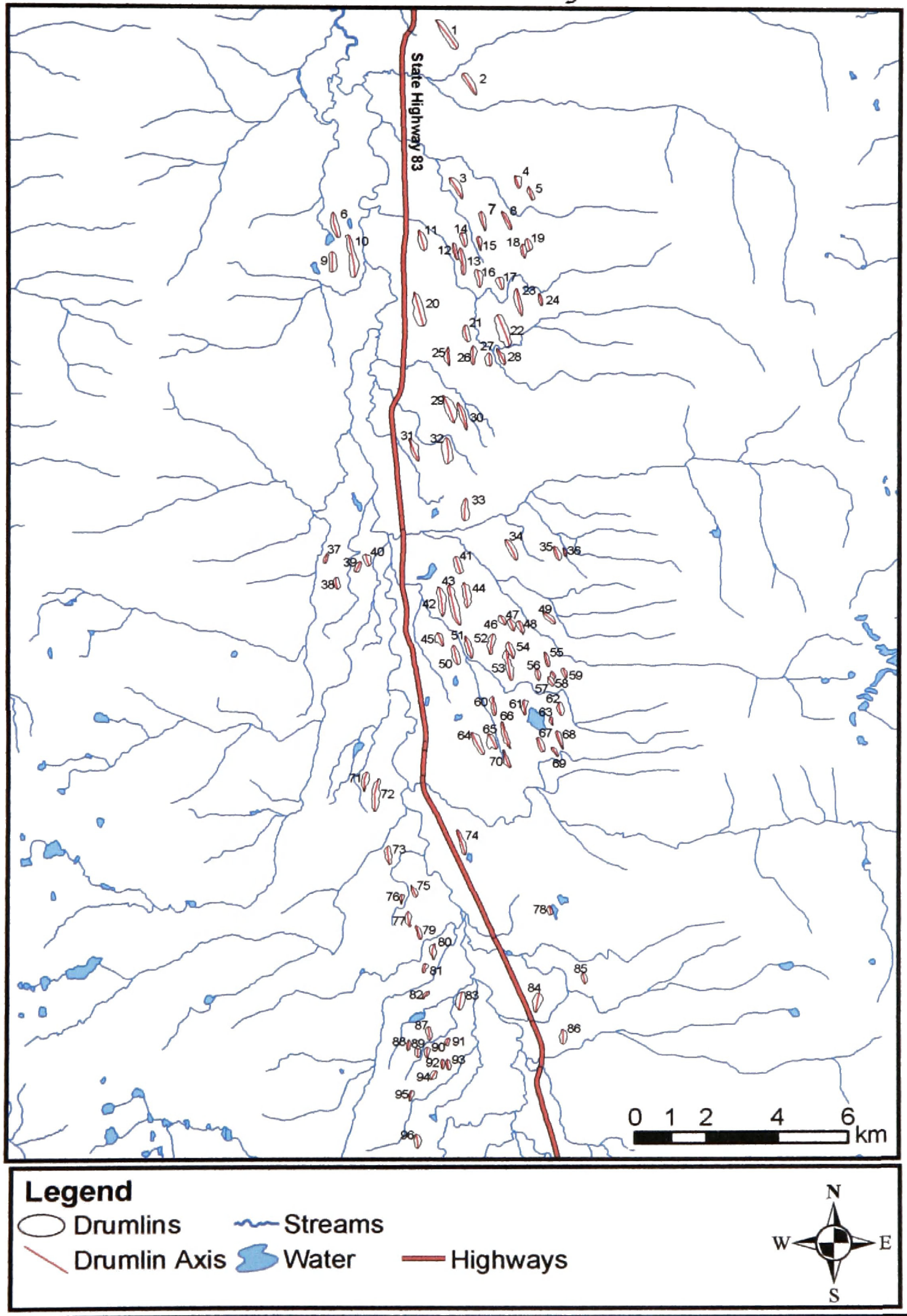
# USGS Quadrangle Index Map



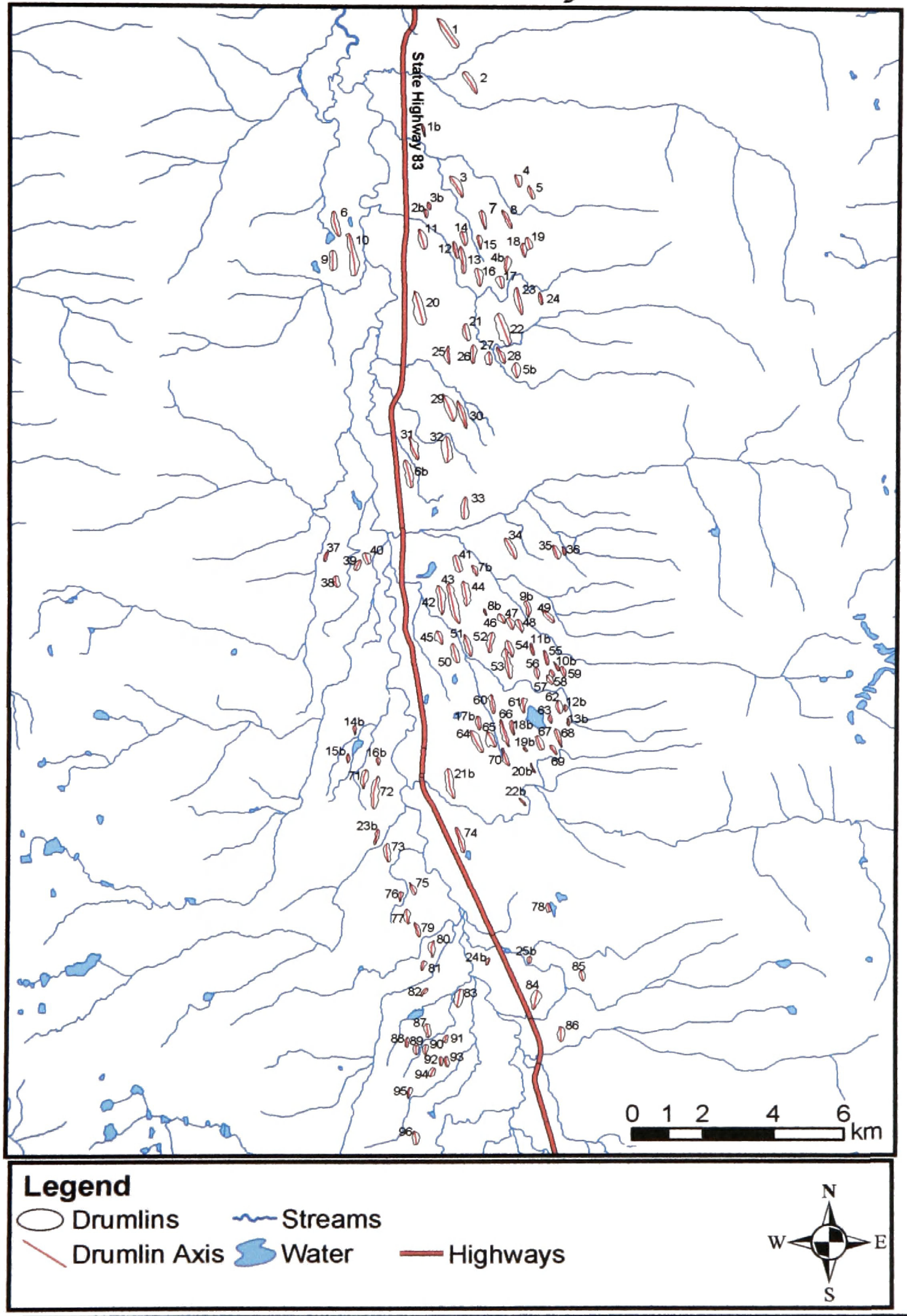
# APPENDIX C

**Drumlin ID & Axis Maps**

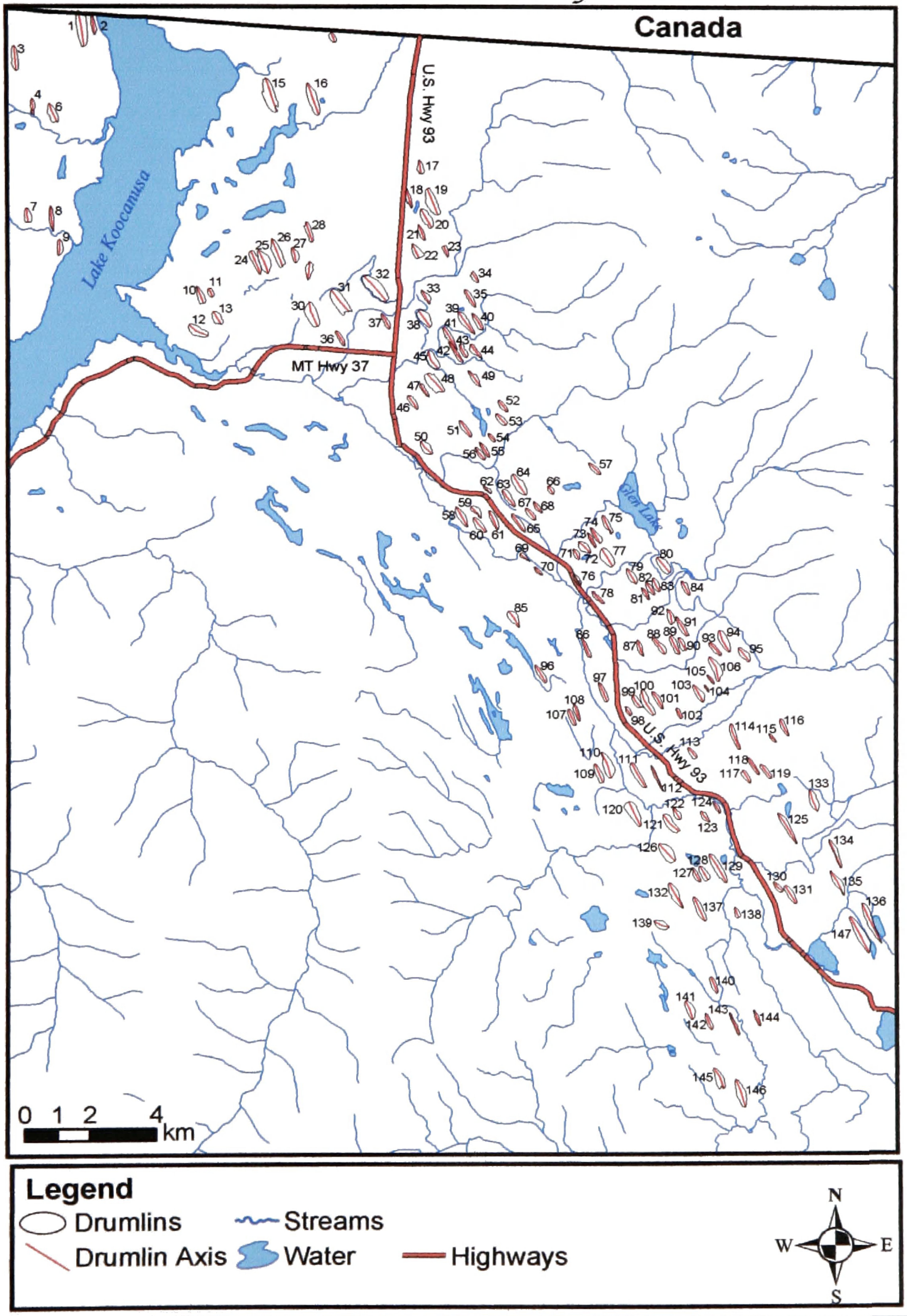
# Drumlin ID & Axis Map
## Seeley/Swan Valley
### Drumlin Delineation Definition #1



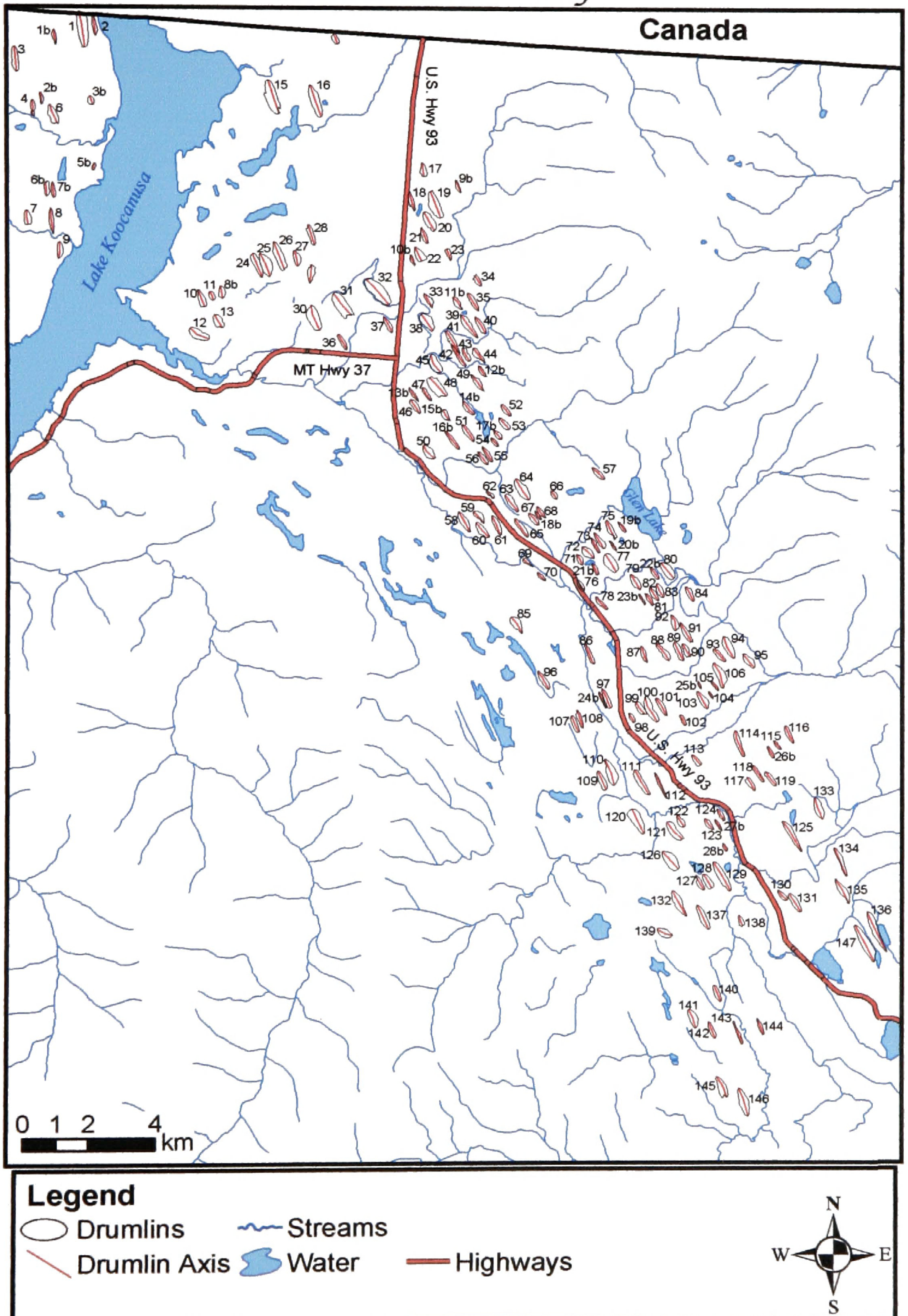
# Drumlin ID & Axis Map
## Seeley/Swan Valley
### Drumlin Delineation Definition #2



# Drumlin ID & Axis Map
# Tobacco Plains/Stillwater Valley
## Drumlin Delineation Definition #1



# Drumlin ID & Axis Map
# Tobacco Plains/Stillwater Valley
## Drumlin Delineation Definition #2



# APPENDIX D

**National Map Accuracy Standards**

# National Mapping Program Standards

## *United States National Map Accuracy Standards*

With a view to the utmost economy and expedition in producing maps which fulfill not only the broad needs for standard or principal maps, but also the reasonable particular needs of individual agencies, standards of accuracy for published maps are defined as follows:

1. **Horizontal accuracy.** For maps on publication scales larger than 1:20,000, not more than 10 percent of the points tested shall be in error by more than 1/30 inch, measured on the publication scale; for maps on publication scales of 1:20,000 or smaller, 1/50 inch. These limits of accuracy shall apply in all cases to positions of well-defined points only. Well-defined points are those that are easily visible or recoverable on the ground, such as the following: monuments or markers, such as bench marks, property boundary monuments; intersections of roads, railroads, etc.; corners of large buildings or structures (or center points of small buildings); etc. In general what is well defined will be determined by what is plottable on the scale of the map within 1/100 inch. Thus while the intersection of two road or property lines meeting at right angles would come within a sensible interpretation, identification of the intersection of such lines meeting at an acute angle would obviously not be practicable within 1/100 inch. Similarly, features not identifiable upon the ground within close limits are not to be considered as test points within the limits quoted, even though their positions may be scaled closely upon the map. In this class would come timber lines, soil boundaries, etc.
2. **Vertical accuracy,** as applied to contour maps on all publication scales, shall be such that not more than 10 percent of the elevations tested shall be in error more than one-half the contour interval. In checking elevations taken from the map, the apparent vertical error may be decreased by assuming a horizontal displacement within the permissible horizontal error for a map of that scale.
3. **The accuracy of any map may be tested** by comparing the positions of points whose locations or elevations are shown upon it with corresponding positions as determined by surveys of a higher accuracy. Tests shall be made by the producing agency, which shall also determine which of its maps are to be tested, and the extent of the testing.
4. **Published maps meeting these accuracy requirements** shall note this fact on their legends, as follows: "This map complies with National Map accuracy Standards."

5. **Published maps whose errors exceed those aforestated** shall omit from their legends all mention of standard accuracy.
6. **When a published map is a considerable enlargement** of a map drawing (manuscript) or of a published map, that fact shall be stated in the legend. For example, "This map is an enlargement of a 1:20,000-scale map drawing," or "This map is an enlargement of a 1:24,000-scale published map."
7. **To facilitate ready interchange and use of basic information for map construction** among all Federal mapmaking agencies, manuscript maps and published maps, wherever economically feasible and consistent with the uses to which the map is to be put, shall conform to latitude and longitude boundaries, being 15 minutes of latitude and longitude, or 7.5 minutes, or 3-3/4 minutes in size.

U.S. BUREAU OF THE BUDGET

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# APPENDIX E

**Raw Data Tables**

# Seeley/Swan Valley Data – Drumlin Delineation Definition #1

| Drum_ID | DL (m) | DW (m) | DH (m) | $DA_b$ (m$^2$) | $DL_I$ | $DL_d$ | DO | $DS_L$ | $DS_I$ | $DS_d$ | DCR | K | L/W | L/H | W/H | L/S | DV (m$^3$) | DNN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Min | 216.87 | 90.61 | 12.80 | 18652.30 | 125.45 | 78.67 | 224.00 | 0.097 | 0.017 | 0.030 | 0.4916 | 1.50 | 1.54 | 11.86 | 5.64 | 0.25 | 76669.08 | 148.80 |
| Max | 1275.41 | 314.76 | 27.43 | 260509.00 | 986.44 | 501.44 | 305.53 | 0.355 | 0.132 | 0.232 | 0.7838 | 6.17 | 5.26 | 83.69 | 20.65 | 1.00 | 1347160.60 | 2249.59 |
| Range | 1058.55 | 224.15 | 14.63 | 241856.70 | 860.99 | 422.76 | 81.53 | 0.26 | 0.12 | 0.20 | 0.29 | 4.68 | 3.71 | 71.83 | 15.01 | 0.75 | 1270491.52 | 2100.78 |
| Average (µ) | 535.15 | 182.89 | 16.69 | 78577.94 | 319.50 | 215.65 | 257.94 | 0.196 | 0.064 | 0.090 | 0.6402 | 3.07 | 2.93 | 32.71 | 11.22 | 0.72 | 371746.14 | 666.47 |
| STDEV (σ) | 229.34 | 48.38 | 2.69 | 51523.59 | 160.33 | 89.39 | 13.62 | 0.060 | 0.029 | 0.038 | 0.0664 | 1.04 | 0.94 | 14.46 | 3.47 | 0.19 | 254997.65 | 409.11 |
| Skewness | 1.06 | 0.53 | 1.80 | 1.63 | 1.56 | 1.13 | 0.74 | 0.64 | 0.52 | 1.00 | -0.24 | 0.80 | 0.73 | 0.94 | 0.70 | -0.61 | 1.59 | 1.48 |
| Kurtosis | 0.82 | 0.14 | 3.79 | 2.76 | 3.34 | 1.07 | 1.50 | -0.17 | -0.63 | 1.46 | -0.66 | 0.16 | -0.22 | 0.60 | 0.20 | -0.47 | 2.51 | 2.22 |
| Coefficient of Variance (CV) | 42.86 | 26.45 | 16.13 | 65.57 | 50.18 | 41.45 | 5.28 | 30.87 | 44.90 | 42.03 | 10.37 | 33.95 | 32.24 | 44.20 | 30.94 | 26.03 | 68.59 | 61.38 |
| 1 | 1032.66 | 219.73 | 18.29 | 194429.00 | 645.08 | 387.58 | 233.39 | 0.166 | 0.028 | 0.047 | 0.5198 | 4.31 | 4.70 | 56.47 | 12.02 | 0.60 | 879754.38 | 1482.07 |
| 2 | 753.05 | 196.95 | 15.24 | 119718.00 | 393.16 | 359.89 | 242.20 | 0.155 | 0.039 | 0.042 | 0.5483 | 3.72 | 3.82 | 49.41 | 12.92 | 0.92 | 479192.77 | 1482.07 |
| 3 | 721.82 | 214.93 | 15.24 | 112269.00 | 530.49 | 191.33 | 236.71 | 0.142 | 0.029 | 0.080 | 0.5782 | 3.64 | 3.36 | 47.36 | 14.10 | 0.36 | 501249.44 | 1042.04 |
| 4 | 396.60 | 200.10 | 21.34 | 57010.10 | 227.14 | 169.46 | 249.36 | 0.213 | 0.094 | 0.126 | 0.7034 | 2.17 | 1.98 | 18.59 | 9.38 | 0.75 | 358954.61 | 491.06 |
| 5 | 418.29 | 125.55 | 15.24 | 44535.50 | 216.90 | 201.39 | 251.53 | 0.243 | 0.070 | 0.076 | 0.6204 | 3.09 | 3.33 | 27.45 | 8.24 | 0.93 | 169674.90 | 491.06 |
| 6 | 784.79 | 205.83 | 15.24 | 124098.00 | 471.20 | 313.59 | 252.18 | 0.148 | 0.032 | 0.049 | 0.5992 | 3.90 | 3.81 | 51.49 | 13.51 | 0.67 | 521909.79 | 1257.95 |
| 7 | 590.01 | 164.62 | 27.43 | 68227.00 | 318.69 | 271.32 | 256.13 | 0.333 | 0.086 | 0.101 | 0.5685 | 4.01 | 3.58 | 21.51 | 6.00 | 0.85 | 564869.29 | 618.15 |
| 8 | 604.67 | 128.58 | 15.24 | 62152.80 | 328.69 | 275.98 | 241.56 | 0.237 | 0.046 | 0.055 | 0.5258 | 4.62 | 4.70 | 39.68 | 8.44 | 0.84 | 251206.79 | 704.56 |
| 9 | 610.95 | 214.69 | 27.43 | 111353.00 | 383.72 | 227.23 | 268.02 | 0.256 | 0.071 | 0.121 | 0.7310 | 2.63 | 2.85 | 22.27 | 7.83 | 0.59 | 762790.81 | 598.99 |
| 10 | 1275.41 | 271.02 | 15.24 | 235909.00 | 903.45 | 371.96 | 259.29 | 0.112 | 0.017 | 0.041 | 0.5172 | 5.42 | 4.71 | 83.69 | 17.78 | 0.41 | 1116805.87 | 598.99 |
| 11 | 625.72 | 241.63 | 15.24 | 109335.00 | 325.28 | 300.44 | 254.40 | 0.126 | 0.047 | 0.051 | 0.6667 | 2.81 | 2.59 | 41.06 | 15.85 | 0.92 | 488501.15 | 961.93 |
| 12 | 514.85 | 111.79 | 15.24 | 49094.50 | 293.02 | 221.83 | 256.65 | 0.273 | 0.052 | 0.069 | 0.5818 | 4.24 | 4.61 | 33.78 | 7.34 | 0.76 | 185951.59 | 414.39 |
| 13 | 824.35 | 175.93 | 21.34 | 105025.00 | 619.22 | 205.13 | 260.33 | 0.243 | 0.034 | 0.104 | 0.5478 | 5.08 | 4.69 | 38.64 | 8.25 | 0.33 | 655993.40 | 569.01 |
| 14 | 450.77 | 188.14 | 15.24 | 66402.80 | 225.53 | 225.24 | 250.63 | 0.162 | 0.068 | 0.068 | 0.6977 | 2.40 | 2.40 | 29.58 | 12.35 | 1.00 | 274010.55 | 414.39 |
| 15 | 430.24 | 140.98 | 15.24 | 40663.70 | 308.54 | 121.70 | 258.73 | 0.216 | 0.049 | 0.125 | 0.6011 | 3.58 | 3.05 | 28.23 | 9.25 | 0.39 | 195979.28 | 418.75 |
| 16 | 554.36 | 226.80 | 21.34 | 87690.50 | 311.93 | 242.42 | 255.94 | 0.188 | 0.068 | 0.088 | 0.6565 | 2.75 | 2.44 | 25.98 | 10.63 | 0.78 | 568708.63 | 569.01 |
| 17 | 378.83 | 240.42 | 15.24 | 66495.90 | 196.08 | 182.75 | 253.93 | 0.127 | 0.078 | 0.083 | 0.7309 | 1.70 | 1.58 | 24.86 | 15.78 | 0.93 | 294268.62 | 611.96 |
| 18 | 422.63 | 160.56 | 15.24 | 50296.30 | 220.11 | 202.51 | 256.43 | 0.190 | 0.069 | 0.075 | 0.6632 | 2.79 | 2.63 | 27.73 | 10.54 | 0.92 | 219235.73 | 251.66 |
| 19 | 370.77 | 197.21 | 15.24 | 59641.90 | 185.51 | 185.26 | 257.20 | 0.155 | 0.082 | 0.082 | 0.7579 | 1.81 | 1.88 | 24.33 | 12.94 | 1.00 | 236246.07 | 251.66 |
| 20 | 1040.68 | 313.38 | 15.24 | 247700.00 | 539.24 | 501.44 | 254.60 | 0.097 | 0.028 | 0.030 | 0.6146 | 3.43 | 3.32 | 68.29 | 20.56 | 0.93 | 1053688.50 | 1478.30 |
| 21 | 513.17 | 197.13 | 15.24 | 80597.70 | 306.70 | 206.48 | 255.51 | 0.155 | 0.050 | 0.074 | 0.6689 | 2.57 | 2.60 | 33.67 | 12.93 | 0.67 | 326843.61 | 840.50 |
| 22 | 998.34 | 314.76 | 15.24 | 260509.00 | 523.62 | 474.71 | 248.78 | 0.097 | 0.029 | 0.032 | 0.6256 | 3.00 | 3.17 | 65.51 | 20.65 | 0.91 | 1015263.23 | 797.48 |
| 23 | 837.53 | 182.09 | 15.24 | 115784.00 | 470.95 | 366.58 | 259.33 | 0.167 | 0.032 | 0.042 | 0.5298 | 4.76 | 4.60 | 54.96 | 11.95 | 0.78 | 492744.76 | 627.03 |
| 24 | 377.97 | 105.48 | 15.24 | 30701.90 | 219.03 | 158.94 | 256.83 | 0.289 | 0.070 | 0.096 | 0.6459 | 3.65 | 3.58 | 24.80 | 6.92 | 0.73 | 128816.53 | 627.03 |
| 25 | 540.46 | 155.51 | 15.24 | 57889.20 | 307.94 | 232.52 | 269.23 | 0.196 | 0.049 | 0.066 | 0.5954 | 3.96 | 3.48 | 35.46 | 10.20 | 0.76 | 271547.88 | 721.59 |
| 26 | 568.76 | 188.42 | 15.24 | 71632.60 | 394.58 | 174.18 | 270.23 | 0.162 | 0.039 | 0.087 | 0.5945 | 3.55 | 3.02 | 37.32 | 12.36 | 0.44 | 346243.03 | 461.58 |
| 27 | 404.17 | 198.67 | 15.24 | 61724.20 | 208.60 | 195.57 | 261.09 | 0.153 | 0.073 | 0.078 | 0.7162 | 2.08 | 2.03 | 26.52 | 13.04 | 0.94 | 259431.57 | 360.79 |
| 28 | 539.56 | 161.59 | 21.34 | 62117.50 | 307.91 | 231.66 | 241.80 | 0.264 | 0.069 | 0.092 | 0.6000 | 3.68 | 3.34 | 25.29 | 7.57 | 0.75 | 394380.20 | 360.79 |
| 29 | 893.99 | 303.24 | 15.24 | 185229.00 | 513.10 | 380.89 | 251.27 | 0.101 | 0.030 | 0.040 | 0.6101 | 3.39 | 2.95 | 58.66 | 19.90 | 0.74 | 875887.93 | 440.41 |
| 30 | 882.82 | 167.89 | 15.24 | 105051.00 | 508.64 | 374.18 | 255.35 | 0.182 | 0.030 | 0.041 | 0.4916 | 5.83 | 5.26 | 57.93 | 11.02 | 0.74 | 478863.32 | 440.41 |
| 31 | 725.46 | 232.45 | 15.24 | 106646.00 | 367.21 | 358.25 | 252.48 | 0.131 | 0.042 | 0.043 | 0.5785 | 3.88 | 3.12 | 47.60 | 15.25 | 0.98 | 544830.67 | 991.79 |
| 32 | 797.79 | 293.15 | 15.24 | 182836.00 | 486.82 | 310.97 | 262.18 | 0.104 | 0.031 | 0.049 | 0.6825 | 2.73 | 2.72 | 52.35 | 19.24 | 0.64 | 755627.62 | 991.79 |
| 33 | 680.87 | 226.00 | 15.24 | 118305.00 | 382.05 | 298.82 | 269.64 | 0.135 | 0.040 | 0.051 | 0.6315 | 3.08 | 3.01 | 44.68 | 14.83 | 0.78 | 497155.35 | 1688.10 |
| 34 | 693.47 | 200.21 | 16.46 | 108001.00 | 407.85 | 285.63 | 244.52 | 0.164 | 0.040 | 0.058 | 0.5834 | 3.50 | 3.46 | 42.13 | 12.16 | 0.70 | 484477.08 | 1291.97 |
| 35 | 451.07 | 178.31 | 17.07 | 60145.50 | 230.29 | 220.78 | 251.44 | 0.191 | 0.074 | 0.077 | 0.6595 | 2.66 | 2.53 | 26.43 | 10.45 | 0.96 | 291046.02 | 239.76 |
| 36 | 261.88 | 90.61 | 15.24 | 18652.30 | 151.15 | 110.74 | 252.01 | 0.336 | 0.101 | 0.138 | 0.6769 | 2.89 | 2.89 | 17.18 | 5.95 | 0.73 | 76669.08 | 239.76 |
| 37 | 304.93 | 98.58 | 15.24 | 24926.10 | 172.43 | 132.51 | 281.71 | 0.309 | 0.088 | 0.115 | 0.6699 | 2.93 | 3.09 | 20.01 | 6.47 | 0.77 | 97122.85 | 813.82 |
| 38 | 352.18 | 163.18 | 15.24 | 49415.40 | 191.14 | 161.05 | 253.78 | 0.187 | 0.080 | 0.095 | 0.6981 | 1.97 | 2.16 | 23.11 | 10.71 | 0.84 | 185683.15 | 813.82 |
| 39 | 341.94 | 158.10 | 15.24 | 44728.20 | 205.27 | 136.67 | 295.04 | 0.193 | 0.074 | 0.112 | 0.7595 | 2.05 | 2.16 | 22.44 | 10.37 | 0.67 | 174668.69 | 295.70 |
| 40 | 356.02 | 222.66 | 15.24 | 62577.30 | 190.28 | 165.74 | 251.95 | 0.137 | 0.080 | 0.092 | 0.6909 | 1.59 | 1.60 | 23.36 | 14.61 | 0.87 | 256111.88 | 295.70 |
| 41 | 532.71 | 214.59 | 15.24 | 94110.40 | 317.56 | 215.16 | 251.29 | 0.142 | 0.048 | 0.071 | 0.6791 | 2.37 | 2.48 | 34.95 | 14.08 | 0.68 | 369338.04 | 1134.60 |
| 42 | 897.68 | 234.16 | 21.34 | 152031.00 | 565.02 | 332.66 | 264.06 | 0.182 | 0.038 | 0.064 | 0.5735 | 4.16 | 3.83 | 42.07 | 10.97 | 0.59 | 950781.76 | 712.24 |
| 43 | 1247.93 | 238.66 | 21.34 | 230172.00 | 986.44 | 261.50 | 257.14 | 0.179 | 0.022 | 0.082 | 0.5272 | 5.31 | 5.23 | 58.49 | 11.19 | 0.27 | 1347160.60 | 549.48 |
| 44 | 761.91 | 228.37 | 15.24 | 133541.00 | 610.53 | 151.38 | 260.16 | 0.133 | 0.025 | 0.101 | 0.6010 | 3.41 | 3.34 | 49.99 | 14.98 | 0.25 | 562175.25 | 549.48 |
| 45 | 441.29 | 226.38 | 12.80 | 65845.80 | 250.88 | 190.41 | 247.67 | 0.113 | 0.051 | 0.067 | 0.7162 | 2.32 | 1.95 | 34.47 | 17.68 | 0.76 | 271130.08 | 655.89 |
| 46 | 334.69 | 193.11 | 15.24 | 44692.60 | 202.58 | 132.11 | 241.41 | 0.158 | 0.075 | 0.115 | 0.6963 | 1.97 | 1.73 | 21.96 | 12.67 | 0.65 | 208819.68 | 334.51 |
| 47 | 385.39 | 183.27 | 16.46 | 51931.70 | 213.52 | 171.87 | 246.06 | 0.180 | 0.077 | 0.096 | 0.6918 | 2.25 | 2.10 | 23.41 | 11.13 | 0.80 | 246452.56 | 234.39 |
| 48 | 420.29 | 168.77 | 21.34 | 53769.30 | 264.15 | 156.14 | 253.16 | 0.253 | 0.081 | 0.137 | 0.6395 | 2.58 | 2.49 | 19.70 | 7.91 | 0.59 | 320837.69 | 234.39 |
| 49 | 454.22 | 172.00 | 15.24 | 62100.60 | 257.59 | 196.62 | 224.00 | 0.177 | 0.059 | 0.078 | 0.6135 | 2.61 | 2.64 | 29.80 | 11.29 | 0.76 | 252415.15 | 865.95 |
| 50 | 597.51 | 211.93 | 18.29 | 95415.00 | 319.20 | 278.31 | 253.01 | 0.173 | 0.057 | 0.066 | 0.6381 | 2.94 | 2.82 | 32.67 | 11.59 | 0.87 | 490957.29 | 476.45 |
| 51 | 688.86 | 193.28 | 21.34 | 96775.20 | 467.97 | 220.89 | 252.50 | 0.221 | 0.046 | 0.097 | 0.5783 | 3.85 | 3.56 | 32.29 | 9.06 | 0.47 | 602231.56 | 476.45 |
| 52 | 628.46 | 216.50 | 15.24 | 93427.90 | 387.11 | 241.35 | 273.75 | 0.141 | 0.039 | 0.063 | 0.6233 | 3.32 | 2.90 | 41.24 | 14.21 | 1.60 | 439605.00 | 558.53 |
| 53 | 922.89 | 212.32 | 15.24 | 134723.00 | 648.06 | 274.84 | 260.73 | 0.144 | 0.024 | 0.055 | 0.5295 | 4.97 | 4.35 | 60.56 | 13.93 | 2.36 | 633095.54 | 717.04 |

# Seeley/Swan Valley Data – Drumlin Delineation Definition #1

| Drum_ID | DL (m) | DW (m) | DH (m) | DAb ($m^2$) | $DL_l$ | $DL_{st}$ | DO | $DS_L$ | $DS_l$ | $DS_{st}$ | DCR | K | L/W | L/H | W/H | L/S | DV ($m^3$) | DNN (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 54 | 522.76 | 185.86 | 15.24 | 71059.20 | 354.35 | 168.41 | 251.70 | 0.164 | 0.043 | 0.090 | 0.6341 | 3.02 | 2.81 | 34.30 | 12.20 | 0.48 | 313918.07 | 558.53 |
| 55 | 457.34 | 112.99 | 15.24 | 40212.00 | 256.91 | 200.43 | 255.31 | 0.270 | 0.059 | 0.076 | 0.5724 | 4.09 | 4.05 | 30.01 | 7.41 | 0.78 | 166960.37 | 485.50 |
| 56 | 340.16 | 153.91 | 15.24 | 40633.60 | 180.22 | 159.94 | 258.28 | 0.198 | 0.085 | 0.095 | 0.7431 | 2.24 | 2.21 | 22.32 | 10.10 | 0.89 | 169151.79 | 394.27 |
| 57 | 290.42 | 174.73 | 15.24 | 40263.60 | 150.56 | 139.86 | 233.65 | 0.174 | 0.101 | 0.109 | 0.7223 | 1.65 | 1.66 | 19.06 | 11.47 | 0.93 | 163957.38 | 201.58 |
| 58 | 217.39 | 140.76 | 15.24 | 24298.00 | 125.45 | 91.94 | 240.92 | 0.217 | 0.121 | 0.166 | 0.7385 | 1.53 | 1.54 | 14.26 | 9.24 | 0.73 | 98863.07 | 201.58 |
| 59 | 320.81 | 136.23 | 15.24 | 34389.40 | 182.07 | 138.74 | 253.69 | 0.224 | 0.084 | 0.110 | 0.6918 | 2.35 | 2.35 | 21.05 | 8.94 | 0.76 | 141202.58 | 330.75 |
| 60 | 591.60 | 138.04 | 12.80 | 65850.90 | 340.93 | 250.67 | 259.79 | 0.185 | 0.038 | 0.051 | 0.5744 | 4.17 | 4.29 | 46.21 | 10.78 | 0.74 | 221634.62 | 862.56 |
| 61 | 459.18 | 137.26 | 15.24 | 56212.30 | 239.01 | 220.17 | 266.28 | 0.222 | 0.064 | 0.069 | 0.6445 | 2.95 | 3.35 | 30.13 | 9.01 | 0.92 | 203632.53 | 842.02 |
| 62 | 401.36 | 202.35 | 15.24 | 60380.70 | 205.19 | 196.16 | 253.59 | 0.151 | 0.074 | 0.078 | 0.6857 | 2.10 | 1.98 | 26.34 | 13.28 | 0.96 | 262393.49 | 429.15 |
| 63 | 274.76 | 113.25 | 19.51 | 21553.10 | 157.32 | 117.43 | 252.40 | 0.345 | 0.124 | 0.166 | 0.6539 | 2.75 | 2.43 | 14.08 | 5.81 | 0.75 | 128677.83 | 429.15 |
| 64 | 730.96 | 220.52 | 15.24 | 121747.00 | 405.84 | 325.12 | 239.83 | 0.138 | 0.038 | 0.047 | 0.6079 | 3.45 | 3.31 | 47.96 | 14.47 | 0.80 | 520801.53 | 431.29 |
| 65 | 503.54 | 264.31 | 15.24 | 97597.40 | 288.55 | 214.99 | 242.37 | 0.115 | 0.053 | 0.071 | 0.6579 | 2.04 | 1.91 | 33.04 | 17.34 | 0.75 | 430004.73 | 403.52 |
| 66 | 834.34 | 159.93 | 15.24 | 88549.50 | 426.22 | 408.12 | 249.44 | 0.191 | 0.036 | 0.037 | 0.5064 | 6.17 | 5.22 | 54.75 | 10.49 | 0.96 | 431120.20 | 403.52 |
| 67 | 428.53 | 176.56 | 15.24 | 63465.90 | 279.20 | 149.33 | 248.29 | 0.173 | 0.055 | 0.102 | 0.6310 | 2.27 | 2.43 | 28.12 | 11.58 | 0.53 | 244452.39 | 380.58 |
| 68 | 571.79 | 135.55 | 19.51 | 54902.60 | 377.18 | 194.62 | 249.51 | 0.288 | 0.052 | 0.100 | 0.5492 | 4.68 | 4.22 | 29.31 | 6.95 | 0.52 | 320529.46 | 421.32 |
| 69 | 336.77 | 123.91 | 15.24 | 29437.50 | 200.08 | 136.69 | 233.85 | 0.246 | 0.076 | 0.111 | 0.6267 | 3.03 | 2.72 | 22.10 | 8.13 | 0.68 | 134818.96 | 380.58 |
| 70 | 569.42 | 164.11 | 12.80 | 57949.40 | 397.73 | 171.68 | 251.49 | 0.156 | 0.032 | 0.075 | 0.5333 | 4.39 | 3.47 | 44.48 | 12.82 | 0.43 | 253613.06 | 800.96 |
| 71 | 593.70 | 196.53 | 15.24 | 85607.10 | 378.16 | 215.55 | 271.43 | 0.155 | 0.040 | 0.071 | 0.6610 | 3.23 | 3.02 | 38.96 | 12.90 | 0.57 | 376981.65 | 542.42 |
| 72 | 995.79 | 224.07 | 21.34 | 166764.00 | 521.18 | 474.61 | 268.72 | 0.190 | 0.041 | 0.045 | 0.5786 | 4.67 | 4.44 | 46.67 | 10.50 | 0.91 | 1009249.28 | 542.42 |
| 73 | 558.71 | 175.08 | 14.63 | 77516.30 | 384.16 | 174.55 | 260.82 | 0.167 | 0.038 | 0.084 | 0.6689 | 3.16 | 3.19 | 38.19 | 11.97 | 0.45 | 303395.11 | 1419.98 |
| 74 | 787.16 | 166.24 | 15.24 | 95386.60 | 540.10 | 247.07 | 251.22 | 0.183 | 0.028 | 0.062 | 0.5189 | 5.10 | 4.74 | 51.65 | 10.91 | 0.46 | 422785.27 | 1918.27 |
| 75 | 383.89 | 151.98 | 21.34 | 40960.10 | 215.87 | 168.02 | 243.94 | 0.281 | 0.099 | 0.127 | 0.6327 | 2.83 | 2.53 | 17.99 | 7.12 | 0.78 | 263911.58 | 394.07 |
| 76 | 294.19 | 120.33 | 21.34 | 25247.60 | 186.38 | 107.81 | 274.26 | 0.355 | 0.114 | 0.198 | 0.6253 | 2.69 | 2.44 | 13.79 | 5.64 | 0.58 | 160127.58 | 394.07 |
| 77 | 454.71 | 180.95 | 15.24 | 57983.10 | 263.92 | 190.80 | 262.63 | 0.168 | 0.058 | 0.080 | 0.6545 | 2.80 | 2.51 | 29.84 | 11.87 | 0.72 | 265843.37 | 587.14 |
| 78 | 269.10 | 131.40 | 15.24 | 30076.10 | 155.34 | 113.75 | 258.66 | 0.232 | 0.098 | 0.134 | 0.7382 | 1.89 | 2.05 | 17.66 | 8.62 | 0.73 | 114239.38 | 2249.59 |
| 79 | 443.18 | 127.95 | 15.24 | 45727.00 | 298.39 | 144.79 | 249.72 | 0.238 | 0.051 | 0.105 | 0.6086 | 3.37 | 3.46 | 29.08 | 8.40 | 0.49 | 183207.64 | 583.22 |
| 80 | 506.82 | 180.96 | 15.24 | 60178.50 | 293.95 | 212.87 | 263.98 | 0.168 | 0.052 | 0.072 | 0.6445 | 3.35 | 2.80 | 33.26 | 11.87 | 0.72 | 296323.98 | 583.22 |
| 81 | 288.99 | 158.23 | 15.24 | 31264.70 | 153.74 | 135.25 | 277.55 | 0.193 | 0.099 | 0.113 | 0.6890 | 2.10 | 1.83 | 18.96 | 10.38 | 0.88 | 147738.07 | 586.63 |
| 82 | 284.76 | 117.78 | 15.24 | 24653.60 | 200.33 | 84.43 | 305.53 | 0.259 | 0.076 | 0.181 | 0.6025 | 2.58 | 2.42 | 18.68 | 7.73 | 0.42 | 108359.09 | 756.98 |
| 83 | 545.33 | 251.44 | 15.24 | 110789.00 | 406.74 | 138.59 | 277.08 | 0.121 | 0.037 | 0.110 | 0.7251 | 2.11 | 2.17 | 35.78 | 16.50 | 0.34 | 443023.80 | 949.56 |
| 84 | 570.59 | 273.13 | 15.24 | 108943.00 | 292.89 | 277.70 | 279.60 | 0.112 | 0.052 | 0.055 | 0.6778 | 2.35 | 2.09 | 37.44 | 17.92 | 0.95 | 503524.78 | 1270.71 |
| 85 | 326.15 | 165.33 | 18.29 | 41738.90 | 166.97 | 159.19 | 279.60 | 0.221 | 0.110 | 0.115 | 0.6822 | 2.00 | 1.97 | 17.83 | 9.04 | 0.95 | 209057.97 | 1486.92 |
| 86 | 442.59 | 220.67 | 18.29 | 70736.10 | 237.61 | 204.98 | 269.32 | 0.166 | 0.077 | 0.089 | 0.6806 | 2.17 | 2.01 | 24.20 | 12.07 | 0.86 | 378650.85 | 1270.71 |
| 87 | 414.85 | 162.81 | 18.29 | 55010.30 | 215.64 | 199.21 | 261.22 | 0.225 | 0.085 | 0.092 | 0.6865 | 2.46 | 2.55 | 22.68 | 8.90 | 0.92 | 261864.95 | 552.77 |
| 88 | 304.70 | 117.87 | 18.29 | 27247.50 | 156.26 | 148.45 | 275.14 | 0.310 | 0.117 | 0.123 | 0.6818 | 2.68 | 2.59 | 16.66 | 6.45 | 0.95 | 139248.77 | 349.45 |
| 89 | 269.16 | 159.33 | 18.29 | 38044.30 | 149.22 | 119.95 | 266.99 | 0.230 | 0.123 | 0.152 | 0.7838 | 1.50 | 1.69 | 14.72 | 8.71 | 0.80 | 166274.32 | 252.82 |
| 90 | 313.68 | 158.87 | 18.29 | 37751.00 | 186.28 | 127.40 | 266.21 | 0.230 | 0.098 | 0.144 | 0.7264 | 2.05 | 1.97 | 17.15 | 8.69 | 0.68 | 193214.49 | 252.82 |
| 91 | 216.87 | 133.99 | 18.29 | 24445.40 | 138.19 | 78.67 | 287.66 | 0.273 | 0.132 | 0.232 | 0.7215 | 1.51 | 1.62 | 11.86 | 7.33 | 0.57 | 112659.72 | 552.77 |
| 92 | 279.49 | 120.67 | 18.29 | 25974.10 | 145.66 | 133.83 | 266.28 | 0.303 | 0.126 | 0.137 | 0.6934 | 2.36 | 2.32 | 15.28 | 6.60 | 0.92 | 130756.61 | 148.80 |
| 93 | 310.51 | 136.83 | 18.29 | 33719.50 | 160.71 | 149.79 | 258.84 | 0.267 | 0.114 | 0.122 | 0.6738 | 2.25 | 2.27 | 16.98 | 7.48 | 0.93 | 164721.93 | 148.80 |
| 94 | 286.41 | 174.72 | 18.29 | 37446.20 | 155.20 | 131.21 | 294.25 | 0.209 | 0.118 | 0.139 | 0.7093 | 1.72 | 1.64 | 15.66 | 9.55 | 0.85 | 194021.83 | 402.06 |
| 95 | 326.73 | 129.40 | 18.29 | 31181.10 | 212.82 | 113.91 | 277.73 | 0.283 | 0.086 | 0.161 | 0.6738 | 2.69 | 2.52 | 17.87 | 7.08 | 0.54 | 163922.37 | 861.14 |
| 96 | 417.54 | 210.88 | 18.29 | 62538.00 | 210.09 | 207.45 | 256.28 | 0.173 | 0.087 | 0.088 | 0.7011 | 2.19 | 1.98 | 22.83 | 11.53 | 0.99 | 341385.79 | 1419.74 |

# Seeley/Swan Valley Data – Drumlin Delineation Definition #2

| Drum_ID | DL (m) | DW (m) | DH (m) | $DA_b$ ($m^2$) | $DL_s$ | $DL_d$ | DO | $DS_L$ | $DS_B$ | $DS_d$ | DCR | K | L/W | L/H | W/H | L/S | DV ($m^3$) | DNN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Min | 155.75 | 63.49 | 6.71 | 9573.13 | 91.82 | 63.93 | 224.00 | 0.07 | 0.02 | 0.03 | 0.49 | 1.50 | 1.54 | 5.19 | 2.12 | 0.25 | 22567.31 | 148.80 |
| Max | 1275.41 | 314.76 | 27.43 | 260509.00 | 986.44 | 501.44 | 305.53 | 0.35 | 0.33 | 0.47 | 0.78 | 6.17 | 5.67 | 83.69 | 20.65 | 1.00 | 1347160.60 | 2249.59 |
| Range | 1119.66 | 251.27 | 20.73 | 250935.87 | 894.62 | 437.51 | 81.53 | 0.28 | 0.31 | 0.44 | 0.29 | 4.68 | 4.12 | 78.50 | 18.54 | 0.75 | 1324593.29 | 2100.78 |
| Average (μ) | 501.07 | 170.43 | 15.09 | 70354.62 | 298.71 | 202.36 | 258.38 | 0.19 | 0.08 | 0.12 | 0.64 | 3.12 | 2.96 | 28.59 | 9.77 | 0.72 | 315251.45 | 669.37 |
| STDEV (σ) | 230.54 | 54.47 | 3.96 | 51656.00 | 156.53 | 91.14 | 14.15 | 0.06 | 0.06 | 0.08 | 0.07 | 1.06 | 0.96 | 15.48 | 4.27 | 0.18 | 256292.44 | 409.10 |
| Skewness | 1.09 | 0.33 | 0.14 | 1.59 | 1.59 | 1.09 | 0.51 | 0.51 | 1.82 | 1.92 | -0.10 | 0.73 | 0.70 | 0.87 | 0.28 | -0.57 | 1.59 | 1.47 |
| Kurtosis | 0.90 | -0.20 | 0.58 | 2.72 | 3.51 | 1.01 | 1.04 | -0.16 | 3.92 | 3.83 | -0.70 | 0.01 | -0.25 | 0.51 | -0.22 | -0.46 | 2.79 | 2.13 |
| Coefficient of Variance (CV) | 46.01 | 31.96 | 26.23 | 73.42 | 52.40 | 45.04 | 5.47 | 32.32 | 67.67 | 68.73 | 10.67 | 33.86 | 32.51 | 54.16 | 43.70 | 25.48 | 81.30 | 61.12 |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1032.66 | 219.73 | 18.29 | 194429.00 | 645.08 | 387.58 | 233.39 | 0.166 | 0.028 | 0.047 | 0.5198 | 4.31 | 4.70 | 56.47 | 12.02 | 0.60 | 879754.38 | 1482.07 |
| 2 | 753.05 | 196.95 | 15.24 | 119718.00 | 393.16 | 359.89 | 242.20 | 0.155 | 0.039 | 0.042 | 0.5483 | 3.72 | 3.82 | 49.41 | 12.92 | 0.92 | 479192.77 | 1482.07 |
| 3 | 721.82 | 214.93 | 15.24 | 112269.00 | 530.49 | 191.33 | 236.71 | 0.142 | 0.029 | 0.080 | 0.5782 | 3.64 | 3.36 | 47.36 | 14.10 | 0.36 | 501249.44 | 1042.04 |
| 4 | 396.60 | 200.10 | 21.34 | 57010.10 | 227.14 | 169.46 | 249.36 | 0.213 | 0.094 | 0.126 | 0.7034 | 2.17 | 1.98 | 18.59 | 9.38 | 0.75 | 358954.61 | 491.06 |
| 5 | 418.29 | 125.55 | 15.24 | 44535.50 | 216.90 | 201.39 | 251.53 | 0.243 | 0.070 | 0.076 | 0.6204 | 3.09 | 3.33 | 27.45 | 8.24 | 0.93 | 169674.90 | 491.06 |
| 6 | 784.79 | 205.83 | 15.24 | 124098.00 | 471.20 | 313.59 | 252.18 | 0.148 | 0.032 | 0.049 | 0.5992 | 3.90 | 3.81 | 51.49 | 13.51 | 0.67 | 521909.79 | 1257.95 |
| 7 | 590.01 | 164.62 | 27.43 | 68227.00 | 318.69 | 271.32 | 256.13 | 0.333 | 0.086 | 0.101 | 0.5685 | 4.01 | 3.58 | 21.51 | 6.00 | 0.85 | 564869.29 | 618.15 |
| 8 | 604.67 | 128.58 | 15.24 | 62152.80 | 328.69 | 275.98 | 241.56 | 0.237 | 0.046 | 0.055 | 0.5258 | 4.62 | 4.70 | 39.68 | 8.44 | 0.84 | 251206.79 | 704.56 |
| 9 | 610.95 | 214.69 | 27.43 | 111353.00 | 383.72 | 227.23 | 268.02 | 0.256 | 0.071 | 0.121 | 0.7310 | 2.63 | 2.85 | 22.27 | 7.83 | 0.59 | 762790.81 | 598.99 |
| 10 | 1275.41 | 271.02 | 15.24 | 235909.00 | 903.45 | 371.96 | 259.29 | 0.112 | 0.017 | 0.041 | 0.5172 | 5.42 | 4.71 | 83.69 | 17.78 | 0.41 | 1116805.87 | 598.99 |
| 11 | 625.72 | 241.63 | 15.24 | 109335.00 | 325.28 | 300.44 | 254.40 | 0.126 | 0.047 | 0.051 | 0.6667 | 2.81 | 2.59 | 41.06 | 15.85 | 0.92 | 488501.15 | 961.93 |
| 12 | 514.85 | 111.79 | 15.24 | 49094.50 | 293.02 | 221.83 | 255.65 | 0.273 | 0.052 | 0.069 | 0.5818 | 4.24 | 4.61 | 33.78 | 7.34 | 0.76 | 185951.59 | 414.39 |
| 13 | 824.35 | 175.93 | 21.34 | 105025.00 | 619.22 | 205.13 | 260.33 | 0.243 | 0.034 | 0.104 | 0.5478 | 5.08 | 4.69 | 38.64 | 8.25 | 0.33 | 655993.40 | 569.01 |
| 14 | 450.77 | 188.14 | 15.24 | 66402.80 | 225.53 | 225.24 | 250.63 | 0.162 | 0.068 | 0.068 | 0.6977 | 2.40 | 2.40 | 29.58 | 12.35 | 1.00 | 274010.55 | 414.39 |
| 15 | 430.24 | 140.98 | 15.24 | 40663.70 | 308.54 | 121.70 | 258.73 | 0.216 | 0.049 | 0.125 | 0.6011 | 3.58 | 3.05 | 28.23 | 9.25 | 0.39 | 195979.28 | 418.75 |
| 16 | 554.36 | 226.80 | 21.34 | 87690.50 | 311.93 | 242.42 | 255.94 | 0.188 | 0.068 | 0.088 | 0.6565 | 2.75 | 2.44 | 25.98 | 10.63 | 0.78 | 568708.63 | 569.01 |
| 17 | 378.83 | 240.42 | 15.24 | 66495.90 | 196.08 | 182.75 | 253.93 | 0.127 | 0.078 | 0.083 | 0.7309 | 1.70 | 1.58 | 24.86 | 15.78 | 0.93 | 294268.62 | 611.96 |
| 18 | 422.63 | 160.56 | 15.24 | 50296.30 | 220.11 | 202.51 | 256.43 | 0.190 | 0.069 | 0.075 | 0.6632 | 2.79 | 2.63 | 27.73 | 10.54 | 0.92 | 219235.73 | 251.66 |
| 19 | 370.77 | 197.21 | 15.24 | 59641.90 | 185.51 | 185.26 | 257.20 | 0.155 | 0.082 | 0.082 | 0.7579 | 1.81 | 1.88 | 24.33 | 12.94 | 1.00 | 236246.07 | 251.66 |
| 20 | 1040.68 | 313.38 | 15.24 | 247700.00 | 539.24 | 501.44 | 254.60 | 0.097 | 0.028 | 0.030 | 0.6146 | 3.43 | 3.32 | 68.29 | 20.56 | 0.93 | 1053688.50 | 1478.30 |
| 21 | 513.17 | 197.13 | 15.24 | 80597.70 | 306.70 | 206.48 | 255.51 | 0.155 | 0.050 | 0.074 | 0.6689 | 2.57 | 2.60 | 33.67 | 12.93 | 0.67 | 326843.61 | 840.50 |
| 22 | 998.34 | 314.76 | 15.24 | 260509.00 | 523.62 | 474.71 | 248.78 | 0.097 | 0.029 | 0.032 | 0.6256 | 3.00 | 3.17 | 65.51 | 20.65 | 0.91 | 1015263.23 | 797.48 |
| 23 | 837.53 | 182.09 | 15.24 | 115784.00 | 470.95 | 366.58 | 259.33 | 0.167 | 0.032 | 0.042 | 0.5298 | 4.76 | 4.60 | 54.96 | 11.95 | 0.78 | 492744.76 | 627.03 |
| 24 | 377.97 | 105.48 | 15.24 | 30701.90 | 219.03 | 158.94 | 256.83 | 0.289 | 0.070 | 0.096 | 0.6459 | 3.65 | 3.58 | 24.80 | 6.92 | 0.73 | 128816.53 | 627.03 |
| 25 | 540.46 | 155.51 | 15.24 | 57889.20 | 307.94 | 232.52 | 269.23 | 0.196 | 0.049 | 0.066 | 0.5954 | 3.96 | 3.48 | 35.46 | 10.20 | 0.76 | 271547.88 | 721.59 |
| 26 | 568.76 | 188.42 | 15.24 | 71632.60 | 394.58 | 174.18 | 270.23 | 0.162 | 0.039 | 0.087 | 0.5945 | 3.55 | 3.02 | 37.32 | 12.36 | 0.44 | 346243.03 | 461.58 |
| 27 | 404.17 | 198.67 | 15.24 | 61724.20 | 208.60 | 195.57 | 261.09 | 0.153 | 0.073 | 0.078 | 0.7162 | 2.08 | 2.03 | 26.52 | 13.04 | 0.94 | 259431.57 | 360.79 |
| 28 | 539.56 | 161.59 | 21.34 | 62117.50 | 307.91 | 231.66 | 241.80 | 0.264 | 0.069 | 0.092 | 0.6000 | 3.68 | 3.34 | 25.29 | 7.57 | 0.75 | 394380.20 | 360.79 |
| 29 | 893.99 | 303.24 | 15.24 | 185229.00 | 513.10 | 380.89 | 251.27 | 0.101 | 0.030 | 0.040 | 0.6101 | 3.39 | 2.95 | 58.66 | 19.90 | 0.74 | 875887.93 | 440.41 |
| 30 | 882.82 | 167.89 | 15.24 | 105051.00 | 508.64 | 374.18 | 255.35 | 0.182 | 0.030 | 0.041 | 0.4916 | 5.83 | 5.26 | 57.93 | 11.02 | 0.74 | 478863.32 | 440.41 |
| 31 | 725.46 | 232.45 | 15.24 | 106646.00 | 367.21 | 358.25 | 252.48 | 0.131 | 0.042 | 0.043 | 0.5785 | 3.88 | 3.12 | 47.60 | 15.25 | 0.98 | 544830.67 | 991.79 |
| 32 | 797.79 | 293.15 | 15.24 | 182836.00 | 486.82 | 310.97 | 262.18 | 0.104 | 0.031 | 0.049 | 0.6825 | 2.73 | 2.72 | 52.35 | 19.24 | 0.64 | 755627.62 | 991.79 |
| 33 | 680.87 | 226.00 | 15.24 | 118305.00 | 382.05 | 298.82 | 269.64 | 0.135 | 0.040 | 0.051 | 0.6315 | 3.08 | 3.01 | 44.68 | 14.83 | 0.78 | 497155.35 | 1688.10 |
| 34 | 693.47 | 200.21 | 16.46 | 108001.00 | 407.85 | 285.63 | 244.52 | 0.164 | 0.040 | 0.058 | 0.5834 | 3.50 | 3.46 | 42.13 | 12.16 | 0.70 | 484477.08 | 1291.97 |
| 35 | 451.07 | 178.31 | 17.07 | 60145.50 | 230.29 | 220.78 | 251.44 | 0.191 | 0.074 | 0.077 | 0.6595 | 2.66 | 2.53 | 26.43 | 10.45 | 0.96 | 291046.02 | 239.76 |
| 36 | 261.88 | 90.61 | 15.24 | 18652.30 | 151.15 | 110.74 | 252.01 | 0.336 | 0.101 | 0.138 | 0.6769 | 2.89 | 2.89 | 17.18 | 5.95 | 0.73 | 76669.08 | 239.76 |
| 37 | 304.93 | 98.58 | 15.24 | 24926.10 | 172.43 | 132.51 | 281.71 | 0.309 | 0.088 | 0.115 | 0.6699 | 2.93 | 3.09 | 20.01 | 6.47 | 0.77 | 97122.85 | 813.82 |
| 38 | 352.18 | 163.18 | 15.24 | 49415.40 | 191.14 | 161.05 | 253.78 | 0.187 | 0.080 | 0.095 | 0.6981 | 1.97 | 2.16 | 23.11 | 10.71 | 0.84 | 185683.15 | 813.82 |
| 39 | 341.94 | 158.10 | 15.24 | 44728.20 | 205.27 | 136.67 | 295.04 | 0.193 | 0.074 | 0.112 | 0.7595 | 2.05 | 2.16 | 22.44 | 10.37 | 0.67 | 174668.69 | 295.70 |
| 40 | 356.02 | 222.66 | 15.24 | 62577.30 | 190.28 | 165.74 | 251.95 | 0.137 | 0.080 | 0.092 | 0.6909 | 1.59 | 1.60 | 23.36 | 14.61 | 0.87 | 256111.88 | 295.70 |
| 41 | 532.71 | 214.59 | 15.24 | 94110.40 | 317.56 | 215.16 | 251.29 | 0.142 | 0.048 | 0.071 | 0.6791 | 2.37 | 2.48 | 34.95 | 14.08 | 0.68 | 369338.04 | 1134.60 |
| 42 | 897.68 | 234.16 | 21.34 | 152031.00 | 565.02 | 332.66 | 264.06 | 0.182 | 0.038 | 0.064 | 0.5735 | 4.16 | 3.83 | 42.07 | 10.97 | 0.59 | 950781.76 | 712.24 |
| 43 | 1247.93 | 238.66 | 21.34 | 230172.00 | 986.44 | 261.50 | 257.14 | 0.179 | 0.022 | 0.082 | 0.5272 | 5.31 | 5.23 | 58.49 | 11.19 | 0.27 | 1347160.60 | 549.48 |
| 44 | 761.91 | 228.37 | 15.24 | 133541.00 | 610.53 | 151.38 | 260.16 | 0.133 | 0.025 | 0.101 | 0.6010 | 3.41 | 3.34 | 49.99 | 14.98 | 0.25 | 562175.25 | 549.48 |
| 45 | 441.29 | 226.38 | 12.80 | 65845.80 | 250.88 | 190.41 | 247.67 | 0.113 | 0.051 | 0.067 | 0.7162 | 2.32 | 1.95 | 34.47 | 17.68 | 0.76 | 271130.08 | 655.89 |
| 46 | 334.69 | 193.11 | 15.24 | 44692.60 | 202.58 | 132.11 | 241.41 | 0.158 | 0.075 | 0.115 | 0.6963 | 1.97 | 1.73 | 21.96 | 12.67 | 0.65 | 208819.68 | 334.51 |
| 47 | 385.39 | 183.27 | 16.46 | 51931.70 | 213.52 | 171.87 | 246.06 | 0.180 | 0.077 | 0.096 | 0.6918 | 2.25 | 2.10 | 23.41 | 11.13 | 0.80 | 246452.56 | 234.39 |
| 48 | 420.29 | 168.77 | 21.34 | 53769.30 | 264.15 | 156.14 | 253.16 | 0.253 | 0.081 | 0.137 | 0.6395 | 2.58 | 2.49 | 19.70 | 7.91 | 0.59 | 320837.69 | 234.39 |
| 49 | 454.22 | 172.00 | 15.24 | 62100.60 | 257.59 | 196.62 | 224.00 | 0.177 | 0.059 | 0.078 | 0.6135 | 2.61 | 2.64 | 29.80 | 11.29 | 0.76 | 252415.15 | 865.95 |
| 50 | 597.51 | 211.93 | 18.29 | 95415.00 | 319.20 | 278.31 | 253.01 | 0.173 | 0.057 | 0.066 | 0.6381 | 2.94 | 2.82 | 32.67 | 11.59 | 0.87 | 490957.29 | 476.45 |
| 51 | 688.86 | 193.28 | 21.34 | 96775.20 | 467.97 | 220.89 | 252.50 | 0.221 | 0.046 | 0.097 | 0.5783 | 3.85 | 3.56 | 32.29 | 9.06 | 0.47 | 602231.56 | 476.45 |
| 52 | 628.46 | 216.50 | 15.24 | 93427.90 | 387.11 | 241.35 | 273.75 | 0.141 | 0.039 | 0.063 | 0.6233 | 3.32 | 2.90 | 41.24 | 14.21 | 0.62 | 439605.00 | 558.53 |
| 53 | 922.89 | 212.32 | 15.24 | 134723.00 | 648.06 | 274.84 | 260.73 | 0.144 | 0.024 | 0.055 | 0.5295 | 4.97 | 4.35 | 60.56 | 13.93 | 0.42 | 633095.54 | 717.04 |
| 54 | 522.76 | 185.86 | 15.24 | 71059.20 | 354.35 | 168.41 | 251.70 | 0.164 | 0.043 | 0.090 | 0.6341 | 3.02 | 2.81 | 34.30 | 12.20 | 0.48 | 313918.07 | 558.53 |

# Seeley/Swan Valley Data – Drumlin Delineation Definition #2

| Drum_ID | DL (m) | DW (m) | DH (m) | DAb ($m^2$) | $DL_s$ | $DL_{sl}$ | DO | $DS_L$ | $DS_s$ | $DS_{sl}$ | DCR | K | L/W | L/H | W/H | L/S | DV ($m^3$) | DNN (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 55 | 457.34 | 112.99 | 15.24 | 40212.00 | 256.91 | 200.43 | 255.31 | 0.270 | 0.059 | 0.076 | 0.5724 | 4.09 | 4.05 | 30.01 | 7.41 | 0.78 | 166960.37 | 485.50 |
| 56 | 340.16 | 153.91 | 15.24 | 40633.60 | 180.22 | 159.94 | 258.28 | 0.198 | 0.085 | 0.095 | 0.7431 | 2.24 | 2.21 | 22.32 | 10.10 | 0.89 | 169151.79 | 394.27 |
| 57 | 290.42 | 174.73 | 15.24 | 40263.60 | 150.56 | 139.86 | 233.65 | 0.174 | 0.101 | 0.109 | 0.7223 | 1.65 | 1.66 | 19.06 | 11.47 | 0.93 | 163957.38 | 201.58 |
| 58 | 217.39 | 140.76 | 15.24 | 24298.00 | 125.45 | 91.94 | 240.92 | 0.217 | 0.121 | 0.166 | 0.7385 | 1.53 | 1.54 | 14.26 | 9.24 | 0.73 | 98863.07 | 201.58 |
| 59 | 320.81 | 136.23 | 15.24 | 34389.40 | 182.07 | 138.74 | 253.69 | 0.224 | 0.084 | 0.110 | 0.6918 | 2.35 | 2.35 | 21.05 | 8.94 | 0.76 | 141202.58 | 330.75 |
| 60 | 591.60 | 138.04 | 12.80 | 65850.90 | 340.93 | 250.67 | 259.79 | 0.185 | 0.038 | 0.051 | 0.5744 | 4.17 | 4.29 | 46.21 | 10.78 | 0.74 | 221634.62 | 862.56 |
| 61 | 459.18 | 137.26 | 15.24 | 56212.30 | 239.01 | 220.17 | 266.28 | 0.222 | 0.064 | 0.069 | 0.6445 | 2.95 | 3.35 | 30.13 | 9.01 | 0.92 | 203632.53 | 842.02 |
| 62 | 401.36 | 202.35 | 15.24 | 60380.70 | 205.19 | 196.16 | 253.59 | 0.151 | 0.074 | 0.078 | 0.6857 | 2.10 | 1.98 | 26.34 | 13.28 | 0.96 | 262393.49 | 429.15 |
| 63 | 274.76 | 113.25 | 19.51 | 21553.10 | 157.32 | 117.43 | 252.40 | 0.345 | 0.124 | 0.166 | 0.6539 | 2.75 | 2.43 | 14.08 | 5.81 | 0.75 | 128677.83 | 429.15 |
| 64 | 730.96 | 220.52 | 15.24 | 121747.00 | 405.84 | 325.12 | 239.83 | 0.138 | 0.038 | 0.047 | 0.6079 | 3.45 | 3.31 | 47.96 | 14.47 | 0.80 | 520801.53 | 431.29 |
| 65 | 503.54 | 264.31 | 15.24 | 97597.40 | 288.55 | 214.99 | 242.37 | 0.115 | 0.053 | 0.071 | 0.6579 | 2.04 | 1.91 | 33.04 | 17.34 | 0.75 | 430004.73 | 403.52 |
| 66 | 834.34 | 159.93 | 15.24 | 88549.50 | 426.22 | 408.12 | 249.44 | 0.191 | 0.036 | 0.037 | 0.5064 | 6.17 | 5.22 | 54.75 | 10.49 | 0.96 | 431120.20 | 403.52 |
| 67 | 428.53 | 176.56 | 15.24 | 63465.90 | 279.20 | 149.33 | 248.29 | 0.173 | 0.055 | 0.102 | 0.6310 | 2.27 | 2.43 | 28.12 | 11.58 | 0.53 | 244452.39 | 380.58 |
| 68 | 571.79 | 135.55 | 19.51 | 54902.60 | 377.18 | 194.62 | 249.51 | 0.288 | 0.052 | 0.100 | 0.5492 | 4.68 | 4.22 | 29.31 | 6.95 | 0.52 | 320529.46 | 421.32 |
| 69 | 336.77 | 123.91 | 15.24 | 29437.50 | 200.08 | 136.69 | 233.85 | 0.246 | 0.076 | 0.111 | 0.6267 | 3.03 | 2.72 | 22.10 | 8.13 | 0.68 | 134818.96 | 380.58 |
| 70 | 569.42 | 164.11 | 12.80 | 57949.40 | 397.73 | 171.68 | 251.49 | 0.156 | 0.032 | 0.075 | 0.5333 | 4.39 | 3.47 | 44.48 | 12.82 | 0.43 | 253613.06 | 800.96 |
| 71 | 593.70 | 196.53 | 15.24 | 85607.10 | 378.16 | 215.55 | 271.43 | 0.155 | 0.040 | 0.071 | 0.6610 | 3.23 | 3.02 | 38.96 | 12.90 | 0.57 | 376981.65 | 542.42 |
| 72 | 995.79 | 224.07 | 21.34 | 166764.00 | 521.18 | 474.61 | 268.72 | 0.190 | 0.041 | 0.045 | 0.5786 | 4.67 | 4.44 | 46.67 | 10.50 | 0.91 | 1009249.28 | 542.42 |
| 73 | 558.71 | 175.08 | 14.63 | 77516.30 | 384.16 | 174.55 | 260.82 | 0.167 | 0.038 | 0.084 | 0.6689 | 3.16 | 3.19 | 38.19 | 11.97 | 0.45 | 303395.11 | 1419.98 |
| 74 | 787.16 | 166.24 | 15.24 | 95386.60 | 540.10 | 247.07 | 251.22 | 0.183 | 0.028 | 0.062 | 0.5189 | 5.10 | 4.74 | 51.65 | 10.91 | 0.46 | 422785.27 | 1918.27 |
| 75 | 383.89 | 151.98 | 21.34 | 40960.10 | 215.87 | 168.02 | 243.94 | 0.281 | 0.099 | 0.127 | 0.6327 | 2.83 | 2.53 | 17.99 | 7.12 | 0.78 | 263911.58 | 394.07 |
| 76 | 294.19 | 120.33 | 21.34 | 25247.60 | 186.38 | 107.81 | 274.26 | 0.355 | 0.114 | 0.198 | 0.6253 | 2.69 | 2.44 | 13.79 | 5.64 | 0.58 | 160127.58 | 394.07 |
| 77 | 454.71 | 180.95 | 15.24 | 57983.10 | 263.92 | 190.80 | 262.63 | 0.168 | 0.058 | 0.080 | 0.6545 | 2.80 | 2.51 | 29.84 | 11.87 | 0.72 | 265843.37 | 587.14 |
| 78 | 269.10 | 131.40 | 15.24 | 30076.10 | 155.34 | 113.75 | 258.66 | 0.232 | 0.098 | 0.134 | 0.7382 | 1.89 | 2.05 | 17.66 | 8.62 | 0.73 | 114239.38 | 2249.59 |
| 79 | 443.18 | 127.95 | 15.24 | 45727.00 | 298.39 | 144.79 | 249.72 | 0.238 | 0.051 | 0.105 | 0.6086 | 3.37 | 3.46 | 29.08 | 8.40 | 0.49 | 183207.64 | 583.22 |
| 80 | 506.82 | 180.96 | 15.24 | 60178.50 | 293.95 | 212.87 | 263.98 | 0.168 | 0.052 | 0.072 | 0.6445 | 3.35 | 2.80 | 33.26 | 11.87 | 0.72 | 296323.98 | 583.22 |
| 81 | 288.99 | 158.23 | 15.24 | 31264.70 | 153.74 | 135.25 | 277.55 | 0.193 | 0.099 | 0.113 | 0.6890 | 2.10 | 1.83 | 18.96 | 10.38 | 0.88 | 147738.07 | 586.63 |
| 82 | 284.76 | 117.78 | 15.24 | 24653.60 | 200.33 | 84.43 | 305.53 | 0.259 | 0.076 | 0.181 | 0.6025 | 2.58 | 2.42 | 18.68 | 7.73 | 0.42 | 108359.09 | 756.98 |
| 83 | 545.33 | 251.44 | 15.24 | 110789.00 | 406.74 | 138.59 | 277.08 | 0.121 | 0.037 | 0.110 | 0.7251 | 2.11 | 2.17 | 35.78 | 16.50 | 0.34 | 443023.80 | 949.56 |
| 84 | 570.59 | 273.13 | 15.24 | 108943.00 | 292.89 | 277.70 | 279.60 | 0.112 | 0.052 | 0.055 | 0.6778 | 2.35 | 2.09 | 37.44 | 17.92 | 0.95 | 503524.78 | 1270.71 |
| 85 | 326.15 | 165.33 | 18.29 | 41738.90 | 166.97 | 159.19 | 279.60 | 0.221 | 0.110 | 0.115 | 0.6822 | 2.00 | 1.97 | 17.83 | 9.04 | 0.95 | 209057.97 | 1486.92 |
| 86 | 442.59 | 220.67 | 18.29 | 70736.10 | 237.61 | 204.98 | 269.32 | 0.166 | 0.077 | 0.089 | 0.6806 | 2.17 | 2.01 | 24.20 | 12.07 | 0.86 | 378650.85 | 1270.71 |
| 87 | 414.85 | 162.81 | 18.29 | 55010.30 | 215.64 | 199.21 | 261.22 | 0.225 | 0.085 | 0.092 | 0.6865 | 2.46 | 2.55 | 22.68 | 8.90 | 0.92 | 261864.95 | 552.77 |
| 88 | 304.70 | 117.87 | 18.29 | 27247.50 | 156.26 | 148.45 | 275.14 | 0.310 | 0.117 | 0.123 | 0.6818 | 2.68 | 2.59 | 16.66 | 6.45 | 0.95 | 139248.77 | 349.45 |
| 89 | 269.16 | 159.33 | 18.29 | 38044.30 | 149.22 | 119.95 | 266.99 | 0.230 | 0.123 | 0.152 | 0.7838 | 1.50 | 1.69 | 14.72 | 8.71 | 0.80 | 166274.32 | 252.82 |
| 90 | 313.68 | 158.87 | 18.29 | 37751.00 | 186.28 | 127.40 | 266.21 | 0.230 | 0.098 | 0.144 | 0.7264 | 2.05 | 1.97 | 17.15 | 8.69 | 0.68 | 193214.49 | 252.82 |
| 91 | 216.87 | 133.99 | 18.29 | 24445.40 | 138.19 | 78.67 | 287.66 | 0.273 | 0.132 | 0.232 | 0.7215 | 1.51 | 1.62 | 11.86 | 7.33 | 0.57 | 112659.72 | 552.77 |
| 92 | 279.49 | 120.67 | 18.29 | 25974.10 | 145.66 | 133.83 | 266.28 | 0.303 | 0.126 | 0.137 | 0.6934 | 2.36 | 2.32 | 15.28 | 6.60 | 0.92 | 130756.61 | 148.80 |
| 93 | 310.51 | 136.83 | 18.29 | 33719.50 | 160.71 | 149.79 | 258.84 | 0.267 | 0.114 | 0.122 | 0.6738 | 2.25 | 2.27 | 16.98 | 7.48 | 0.93 | 164721.93 | 148.80 |
| 94 | 286.41 | 174.72 | 18.29 | 37446.20 | 155.20 | 131.21 | 294.25 | 0.209 | 0.118 | 0.139 | 0.7093 | 1.72 | 1.64 | 15.66 | 9.55 | 0.85 | 194021.83 | 402.06 |
| 95 | 326.73 | 129.40 | 18.29 | 31181.10 | 212.82 | 113.91 | 277.73 | 0.283 | 0.086 | 0.161 | 0.6738 | 2.69 | 2.52 | 17.87 | 7.08 | 0.54 | 163922.37 | 861.14 |
| 96 | 417.54 | 210.88 | 18.29 | 62538.00 | 210.09 | 207.45 | 256.28 | 0.173 | 0.087 | 0.088 | 0.7011 | 2.19 | 1.98 | 22.83 | 11.53 | 0.99 | 341385.79 | 1419.74 |
| 1b | 411.01 | 72.51 | 9.14 | 21927.85 | 247.85 | 163.16 | 255.87 | 0.252 | 0.121 | 0.184 | 0.5313 | 6.05 | 5.67 | 13.70 | 2.42 | 0.66 | 57769.77 | 1931.83 |
| 2b | 260.79 | 108.44 | 9.14 | 21672.76 | 170.93 | 89.85 | 264.35 | 0.169 | 0.176 | 0.334 | 0.7558 | 2.46 | 2.40 | 8.69 | 3.61 | 0.53 | 54820.64 | 274.40 |
| 3b | 232.97 | 111.67 | 9.14 | 20312.07 | 128.07 | 104.90 | 254.95 | 0.164 | 0.234 | 0.286 | 0.7728 | 2.10 | 2.09 | 7.77 | 3.72 | 0.82 | 50431.75 | 274.40 |
| 4b | 504.40 | 193.25 | 9.14 | 69894.65 | 286.26 | 218.13 | 270.58 | 0.095 | 0.105 | 0.138 | 0.6522 | 2.86 | 2.61 | 16.81 | 6.44 | 0.76 | 188957.04 | 606.90 |
| 5b | 446.47 | 256.47 | 9.14 | 79482.26 | 245.10 | 201.37 | 255.72 | 0.071 | 0.122 | 0.149 | 0.7188 | 1.97 | 1.74 | 14.88 | 8.55 | 0.82 | 221972.61 | 550.58 |
| 6b | 843.06 | 227.92 | 9.14 | 144729.26 | 501.87 | 341.19 | 255.24 | 0.080 | 0.060 | 0.088 | 0.5918 | 3.86 | 3.70 | 28.10 | 7.60 | 0.68 | 372492.96 | 839.00 |
| 7b | 337.12 | 149.38 | 6.71 | 36241.49 | 187.53 | 149.59 | 241.03 | 0.090 | 0.117 | 0.147 | 0.6676 | 2.46 | 2.26 | 15.32 | 6.79 | 0.80 | 71589.43 | 591.71 |
| 8b | 220.10 | 68.88 | 9.14 | 11608.43 | 114.06 | 106.04 | 249.81 | 0.266 | 0.263 | 0.283 | 0.6391 | 3.28 | 3.20 | 7.34 | 2.30 | 0.93 | 29390.09 | 492.67 |
| 9b | 515.63 | 142.95 | 9.14 | 57962.77 | 297.68 | 217.95 | 268.39 | 0.128 | 0.101 | 0.138 | 0.5862 | 3.60 | 3.61 | 17.19 | 4.77 | 0.73 | 142892.55 | 570.65 |
| 10b | 308.47 | 91.05 | 9.14 | 18897.79 | 172.45 | 136.02 | 240.48 | 0.201 | 0.174 | 0.221 | 0.5802 | 3.95 | 3.39 | 10.28 | 3.03 | 0.79 | 54445.40 | 224.01 |
| 11b | 388.17 | 92.72 | 9.14 | 28049.69 | 237.49 | 150.68 | 260.53 | 0.197 | 0.126 | 0.199 | 0.5483 | 4.22 | 4.19 | 12.94 | 3.09 | 0.63 | 69770.94 | 453.93 |
| 12b | 206.03 | 103.28 | 9.14 | 15960.03 | 103.75 | 102.28 | 255.48 | 0.177 | 0.289 | 0.293 | 0.6836 | 2.09 | 1.99 | 6.87 | 3.44 | 0.99 | 41249.00 | 216.71 |
| 13b | 236.55 | 85.77 | 9.14 | 13427.89 | 165.92 | 70.63 | 264.35 | 0.213 | 0.181 | 0.425 | 0.6029 | 3.27 | 2.76 | 7.88 | 2.86 | 0.43 | 39332.58 | 466.81 |
| 14b | 278.69 | 98.02 | 9.14 | 18710.63 | 167.27 | 111.42 | 269.30 | 0.187 | 0.179 | 0.269 | 0.6395 | 3.26 | 2.84 | 9.29 | 3.27 | 0.67 | 52954.30 | 858.73 |
| 15b | 288.05 | 103.00 | 9.14 | 20836.98 | 161.53 | 126.52 | 274.22 | 0.178 | 0.186 | 0.237 | 0.7695 | 3.13 | 2.80 | 9.60 | 3.43 | 0.78 | 57516.13 | 719.63 |
| 16b | 236.22 | 124.00 | 9.14 | 20864.51 | 140.93 | 95.28 | 267.84 | 0.147 | 0.213 | 0.315 | 0.6928 | 2.10 | 1.90 | 7.87 | 4.13 | 0.68 | 56782.82 | 626.08 |
| 17b | 428.42 | 148.55 | 9.14 | 47547.49 | 227.25 | 201.17 | 265.73 | 0.123 | 0.132 | 0.149 | 0.6391 | 3.03 | 2.88 | 14.28 | 4.95 | 0.89 | 123371.22 | 513.21 |
| 18b | 465.60 | 117.02 | 9.14 | 38684.17 | 245.20 | 220.39 | 254.63 | 0.156 | 0.122 | 0.136 | 0.6188 | 4.40 | 3.98 | 15.52 | 3.90 | 0.90 | 105618.31 | 272.12 |
| 19b | 155.75 | 74.75 | 9.14 | 9573.13 | 91.82 | 63.93 | 224.80 | 0.245 | 0.327 | 0.469 | 0.6822 | 1.99 | 2.08 | 5.19 | 2.49 | 0.70 | 22567.31 | 431.90 |
| 20b | 317.00 | 75.86 | 9.14 | 16280.04 | 234.87 | 82.12 | 250.62 | 0.241 | 0.128 | 0.365 | 0.5151 | 4.85 | 4.18 | 10.57 | 2.53 | 0.35 | 46615.84 | 671.47 |
| 21b | 934.36 | 208.57 | 9.14 | 162379.08 | 543.35 | 391.00 | 264.35 | 0.088 | 0.055 | 0.077 | 0.5994 | 4.22 | 4.48 | 31.15 | 6.95 | 0.72 | 377780.82 | 1567.04 |
| 22b | 295.76 | 63.49 | 9.14 | 14857.68 | 202.23 | 93.53 | 229.12 | 0.288 | 0.148 | 0.321 | 0.5453 | 4.62 | 4.66 | 9.86 | 2.12 | 0.46 | 36399.29 | 1021.00 |
| 23b | 479.05 | 119.20 | 6.71 | 39346.55 | 331.91 | 147.14 | 282.71 | 0.113 | 0.066 | 0.150 | 0.5599 | 4.58 | 4.02 | 21.78 | 5.42 | 0.44 | 81177.18 | 534.32 |
| 24b | 243.13 | 98.61 | 9.14 | 17303.62 | 146.80 | 96.33 | 293.74 | 0.185 | 0.204 | 0.311 | 0.6644 | 2.68 | 2.47 | 8.10 | 3.29 | 0.66 | 46477.76 | 1151.57 |
| 25b | 221.92 | 128.82 | 9.14 | 22876.10 | 119.73 | 102.19 | 288.06 | 0.142 | 0.251 | 0.294 | 0.7695 | 1.69 | 1.72 | 7.40 | 4.29 | 0.85 | 55420.01 | 1151.57 |

# Tobacco Plains/Stillwater Valley Data – Drumlin Delineation Definition #1

| Drum_ID | DL (m) | DW (m) | DH (m) | $DA_b$ ($m^2$) | $DL_s$ | $DL_d$ | DO | $DS_l$ | $DS_s$ | $DS_d$ | DCR | K | L/W | L/H | W/H | L/S | DV ($m^3$) | DNN (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Min | 171.2 | 70.8 | 12.8 | 12936.0 | 98.52 | 72.67 | 23.68 | 0.078 | 0.020 | 0.028 | 0.3402 | 1.75 | 1.70 | 11.23 | 3.65 | 0.32 | 52204.10788 | 188.81 |
| Max | 1433.5 | 422.4 | 51.8 | 355242.0 | 908.40 | 647.88 | 97.80 | 0.548 | 0.155 | 0.282 | 0.7351 | 11.21 | 10.65 | 78.38 | 25.51 | 0.99 | 5008882.787 | 2102.30 |
| Range | 1262.3 | 351.6 | 39.0 | 342306.0 | 809.87 | 575.21 | 74.12 | 0.5 | 0.1 | 0.3 | 0.4 | 9.5 | 9.0 | 67.1 | 21.9 | 0.7 | 4956678.7 | 1913.5 |
| Average (μ) | 636.9 | 202.3 | 20.3 | 102827.2 | 380.10 | 256.81 | 62.03 | 0.214 | 0.059 | 0.086 | 0.5934 | 3.49 | 3.33 | 33.27 | 10.55 | 0.71 | 851344.9098 | 648.40 |
| STDEV (σ) | 216.2 | 68.4 | 7.5 | 63958.1 | 146.99 | 90.55 | 10.87 | 0.079 | 0.023 | 0.037 | 0.07 | 1.33 | 1.23 | 11.88 | 3.74 | 0.18 | 645746.53 | 361.14 |
| Skewness | 0.9 | 0.8 | 2.0 | 1.5 | 1.09 | 1.13 | 0.28 | 1.220 | 1.173 | 1.989 | -0.55 | 2.26 | 2.21 | 0.96 | 1.01 | -0.44 | 3.14 | 1.21 |
| Kurtosis | 1.2 | 0.2 | 4.8 | 2.4 | 1.23 | 2.45 | 1.32 | 2.274 | 1.785 | 6.345 | 0.81 | 8.56 | 8.60 | 1.65 | 1.71 | -0.78 | 14.78 | 1.55 |
| Coefficient of Variance (CV) | 33.9 | 33.8 | 36.7 | 62.2 | 38.67 | 35.26 | 17.52 | 36.719 | 40.109 | 42.669 | 12.02 | 38.16 | 37.14 | 35.72 | 35.41 | 25.08 | 99.14 | 55.70 |
| 1 | 1172.1 | 328.3 | 30.8 | 310389.0 | 772.78 | 399.35 | 172.78 | 0.188 | 0.040 | 0.077 | 0.6079 | 3.48 | 3.57 | 38.07 | 10.67 | 0.52 | 2511673.184 | 362.66 |
| 2 | 715.2 | 125.0 | 15.2 | 66954.9 | 393.00 | 322.21 | 172.44 | 0.244 | 0.039 | 0.047 | 0.5184 | 6.00 | 5.72 | 46.93 | 8.20 | 0.82 | 288933.312 | 362.66 |
| 3 | 818.2 | 194.2 | 15.2 | 130036.0 | 415.64 | 402.59 | 175.00 | 0.157 | 0.037 | 0.038 | 0.6035 | 4.04 | 4.21 | 53.69 | 12.74 | 0.97 | 513329.7267 | 1609.67 |
| 4 | 381.3 | 149.2 | 15.2 | 44332.7 | 203.57 | 177.74 | 176.95 | 0.204 | 0.075 | 0.086 | 0.7298 | 2.58 | 2.56 | 25.02 | 9.79 | 0.87 | 183833.5602 | 276.31 |
| 5 | 171.2 | 94.4 | 15.2 | 12936.0 | 98.52 | 72.67 | 160.33 | 0.323 | 0.155 | 0.210 | 0.6864 | 1.78 | 1.81 | 11.23 | 6.19 | 0.74 | 52204.10788 | 276.31 |
| 6 | 644.8 | 266.8 | 21.3 | 129842.0 | 413.76 | 231.03 | 156.57 | 0.160 | 0.052 | 0.092 | 0.6624 | 2.51 | 2.42 | 30.22 | 12.51 | 0.56 | 778218.7491 | 583.94 |
| 7 | 457.2 | 227.0 | 15.2 | 84604.6 | 232.53 | 224.63 | 172.71 | 0.134 | 0.066 | 0.068 | 0.7351 | 1.94 | 2.01 | 30.00 | 14.90 | 0.97 | 335337.2815 | 740.31 |
| 8 | 840.9 | 139.2 | 15.2 | 80814.6 | 508.78 | 332.16 | 173.48 | 0.219 | 0.030 | 0.046 | 0.5067 | 6.87 | 6.04 | 55.18 | 9.14 | 0.65 | 378296.366 | 740.31 |
| 9 | 527.7 | 173.2 | 15.2 | 73339.7 | 276.27 | 251.43 | 187.80 | 0.176 | 0.055 | 0.061 | 0.6728 | 2.98 | 3.05 | 34.63 | 11.37 | 0.91 | 295327.107 | 1055.84 |
| 10 | 578.4 | 197.7 | 15.2 | 90115.7 | 362.45 | 215.95 | 162.00 | 0.154 | 0.042 | 0.071 | 0.6298 | 2.92 | 2.93 | 37.95 | 12.97 | 0.60 | 369360.1801 | 333.44 |
| 11 | 310.1 | 182.0 | 15.2 | 43231.8 | 180.78 | 129.32 | 153.31 | 0.167 | 0.084 | 0.118 | 0.7223 | 1.75 | 1.70 | 20.35 | 11.94 | 0.72 | 182389.9385 | 333.44 |
| 12 | 685.0 | 318.8 | 15.2 | 161733.0 | 395.30 | 289.67 | 113.68 | 0.096 | 0.039 | 0.053 | 0.6955 | 2.28 | 2.15 | 44.95 | 20.92 | 0.73 | 705633.9979 | 764.90 |
| 13 | 486.0 | 272.2 | 15.2 | 101417.0 | 266.09 | 219.91 | 144.85 | 0.112 | 0.057 | 0.069 | 0.7182 | 1.83 | 1.79 | 31.89 | 17.86 | 0.83 | 427405.023 | 764.90 |
| 14 | 335.0 | 181.3 | 15.2 | 50064.6 | 179.64 | 155.33 | 158.12 | 0.168 | 0.085 | 0.098 | 0.6855 | 1.76 | 1.85 | 21.98 | 11.89 | 0.86 | 196187.7836 | 2102.30 |
| 15 | 1153.4 | 350.7 | 16.8 | 315915.0 | 612.04 | 541.32 | 163.02 | 0.096 | 0.027 | 0.031 | 0.5534 | 3.31 | 3.29 | 68.80 | 20.92 | 0.88 | 1437620.021 | 1295.59 |
| 16 | 1091.7 | 273.0 | 27.4 | 227029.0 | 567.29 | 524.40 | 162.54 | 0.201 | 0.048 | 0.052 | 0.5719 | 4.12 | 4.00 | 39.80 | 9.95 | 0.92 | 1733074.002 | 1295.59 |
| 17 | 433.9 | 210.6 | 21.3 | 64945.9 | 246.55 | 187.33 | 173.19 | 0.203 | 0.087 | 0.114 | 0.6789 | 2.28 | 2.06 | 20.34 | 9.87 | 0.76 | 413382.3178 | 1048.32 |
| 18 | 609.7 | 151.7 | 21.3 | 66219.5 | 323.62 | 286.07 | 164.89 | 0.281 | 0.066 | 0.075 | 0.5186 | 4.41 | 4.02 | 28.58 | 7.11 | 0.88 | 418405.6844 | 656.12 |
| 19 | 900.4 | 336.0 | 46.6 | 221728.0 | 630.11 | 270.25 | 159.99 | 0.278 | 0.074 | 0.173 | 0.6006 | 2.87 | 2.68 | 19.31 | 7.20 | 0.43 | 2990813.051 | 656.12 |
| 20 | 694.6 | 271.4 | 21.3 | 144865.0 | 427.88 | 266.76 | 153.09 | 0.157 | 0.050 | 0.080 | 0.6553 | 2.62 | 2.56 | 32.56 | 12.72 | 0.62 | 852787.2082 | 534.46 |
| 21 | 549.6 | 147.8 | 18.6 | 59900.8 | 288.08 | 261.47 | 159.29 | 0.252 | 0.065 | 0.071 | 0.5760 | 3.96 | 3.72 | 29.56 | 7.95 | 0.91 | 320214.2489 | 534.46 |
| 22 | 506.3 | 270.4 | 15.2 | 106715.0 | 286.50 | 219.77 | 157.23 | 0.113 | 0.053 | 0.069 | 0.6667 | 1.89 | 1.87 | 33.22 | 17.74 | 0.77 | 442288.9604 | 671.49 |
| 23 | 381.1 | 150.5 | 22.3 | 42889.3 | 240.92 | 140.18 | 163.43 | 0.296 | 0.092 | 0.159 | 0.6395 | 2.66 | 2.53 | 17.13 | 6.76 | 0.58 | 270515.4694 | 897.85 |
| 24 | 812.1 | 219.0 | 21.3 | 136145.0 | 464.96 | 347.18 | 158.11 | 0.195 | 0.046 | 0.061 | 0.5622 | 3.80 | 3.71 | 38.06 | 10.26 | 0.75 | 804465.6059 | 287.14 |
| 25 | 816.6 | 338.1 | 21.3 | 196924.0 | 421.73 | 394.91 | 154.71 | 0.126 | 0.051 | 0.054 | 0.6726 | 2.66 | 2.42 | 38.27 | 15.85 | 0.94 | 1248872.42 | 287.14 |
| 26 | 966.9 | 255.6 | 33.5 | 200702.0 | 554.37 | 412.51 | 161.25 | 0.262 | 0.060 | 0.081 | 0.5606 | 3.66 | 3.78 | 28.84 | 7.62 | 0.74 | 1756575.118 | 530.30 |
| 27 | 514.6 | 209.4 | 21.3 | 79906.2 | 261.87 | 252.77 | 164.34 | 0.204 | 0.081 | 0.084 | 0.6849 | 2.60 | 2.46 | 24.12 | 9.81 | 0.97 | 487361.5956 | 582.60 |
| 28 | 687.8 | 175.0 | 21.3 | 94193.4 | 414.76 | 273.04 | 162.60 | 0.244 | 0.051 | 0.078 | 0.5703 | 3.94 | 3.93 | 32.24 | 8.20 | 0.66 | 544455.6977 | 944.91 |
| 29 | 609.1 | 229.4 | 21.3 | 91327.4 | 415.38 | 193.67 | 185.53 | 0.186 | 0.051 | 0.110 | 0.6142 | 3.19 | 2.65 | 28.55 | 10.75 | 0.47 | 632093.1496 | 600.30 |
| 30 | 853.5 | 347.8 | 27.4 | 227631.0 | 548.71 | 304.78 | 156.75 | 0.158 | 0.050 | 0.090 | 0.6290 | 2.51 | 2.45 | 31.11 | 12.68 | 0.56 | 1726236.848 | 933.89 |
| 31 | 882.2 | 374.9 | 33.5 | 289032.0 | 461.35 | 420.80 | 139.12 | 0.179 | 0.073 | 0.080 | 0.6207 | 2.11 | 2.35 | 26.31 | 11.18 | 0.91 | 2350616.171 | 933.89 |
| 32 | 1079.5 | 422.4 | 51.8 | 355242.0 | 766.43 | 313.09 | 141.51 | 0.245 | 0.068 | 0.166 | 0.6104 | 2.58 | 2.56 | 20.83 | 8.15 | 0.41 | 5008882.787 | 1158.30 |
| 33 | 514.9 | 172.1 | 15.2 | 59339.6 | 312.49 | 202.42 | 153.83 | 0.177 | 0.049 | 0.075 | 0.5580 | 3.51 | 2.99 | 33.79 | 11.29 | 0.65 | 286344.7135 | 687.44 |
| 34 | 374.3 | 164.5 | 15.2 | 49833.9 | 262.34 | 111.92 | 147.70 | 0.185 | 0.058 | 0.136 | 0.6572 | 2.21 | 2.28 | 24.56 | 10.79 | 0.43 | 198871.2254 | 701.35 |
| 35 | 652.7 | 167.6 | 21.3 | 86619.2 | 409.64 | 243.08 | 150.44 | 0.255 | 0.052 | 0.088 | 0.5573 | 3.86 | 3.89 | 30.59 | 7.86 | 0.59 | 494826.7541 | 701.35 |
| 36 | 553.8 | 139.1 | 21.3 | 64029.1 | 336.25 | 217.59 | 152.82 | 0.307 | 0.063 | 0.098 | 0.5531 | 3.76 | 3.98 | 25.96 | 6.52 | 0.65 | 348537.2024 | 1190.06 |
| 37 | 560.5 | 153.8 | 15.2 | 62928.6 | 346.09 | 214.39 | 156.76 | 0.198 | 0.044 | 0.071 | 0.5704 | 3.92 | 3.64 | 36.78 | 10.09 | 0.62 | 278475.6507 | 1170.17 |
| 38 | 637.9 | 335.2 | 27.4 | 155112.0 | 413.32 | 224.62 | 146.76 | 0.164 | 0.066 | 0.122 | 0.6661 | 2.06 | 1.90 | 23.25 | 12.22 | 0.54 | 1243669.876 | 687.44 |
| 39 | 909.4 | 237.7 | 15.2 | 147061.0 | 637.33 | 272.04 | 143.84 | 0.128 | 0.024 | 0.056 | 0.5230 | 4.42 | 3.83 | 59.67 | 15.60 | 0.43 | 698435.9775 | 509.16 |
| 40 | 641.0 | 168.2 | 21.3 | 87119.8 | 343.76 | 297.20 | 145.43 | 0.254 | 0.062 | 0.072 | 0.5602 | 3.70 | 3.81 | 30.04 | 7.88 | 0.86 | 487676.5435 | 509.16 |
| 41 | 825.3 | 192.1 | 27.4 | 104470.0 | 603.13 | 222.20 | 149.77 | 0.286 | 0.045 | 0.123 | 0.4716 | 5.12 | 4.30 | 30.09 | 7.00 | 0.37 | 922264.1518 | 689.31 |
| 42 | 817.6 | 124.0 | 21.3 | 80694.6 | 540.01 | 277.58 | 148.08 | 0.344 | 0.040 | 0.077 | 0.4215 | 6.51 | 6.59 | 38.32 | 5.81 | 0.51 | 458579.5314 | 229.03 |
| 43 | 478.8 | 169.5 | 15.2 | 65295.2 | 301.49 | 177.26 | 148.53 | 0.180 | 0.051 | 0.086 | 0.6267 | 2.76 | 2.82 | 31.41 | 11.12 | 0.59 | 262207.5922 | 229.03 |
| 44 | 592.6 | 192.5 | 15.2 | 73389.7 | 353.69 | 238.92 | 140.81 | 0.158 | 0.043 | 0.064 | 0.5114 | 3.76 | 3.08 | 38.88 | 12.63 | 0.68 | 368607.9059 | 403.41 |
| 45 | 685.8 | 297.3 | 21.3 | 153810.0 | 391.59 | 294.24 | 140.02 | 0.144 | 0.054 | 0.073 | 0.6660 | 2.40 | 2.31 | 32.14 | 13.93 | 0.75 | 922179.9287 | 650.32 |
| 46 | 532.3 | 178.1 | 15.2 | 74737.7 | 321.72 | 210.58 | 146.27 | 0.171 | 0.047 | 0.072 | 0.5981 | 2.98 | 2.99 | 34.93 | 11.68 | 0.65 | 306258.6714 | 534.31 |
| 47 | 488.7 | 123.3 | 15.2 | 47024.3 | 305.80 | 182.94 | 148.98 | 0.247 | 0.050 | 0.083 | 0.5504 | 3.99 | 3.96 | 32.07 | 8.09 | 0.60 | 194757.1523 | 421.64 |
| 48 | 779.5 | 355.6 | 21.3 | 223377.0 | 544.02 | 235.49 | 140.22 | 0.120 | 0.039 | 0.091 | 0.6504 | 2.14 | 2.19 | 36.53 | 16.67 | 0.43 | 1253887.63 | 421.64 |
| 49 | 662.0 | 187.6 | 15.2 | 78403.3 | 380.96 | 281.08 | 148.88 | 0.162 | 0.040 | 0.054 | 0.5447 | 4.39 | 3.53 | 43.44 | 12.31 | 0.74 | 401309.7069 | 876.21 |
| 50 | 529.5 | 264.1 | 13.7 | 104889.0 | 318.42 | 211.05 | 138.36 | 0.104 | 0.043 | 0.065 | 0.6847 | 2.10 | 2.00 | 38.60 | 19.25 | 0.66 | 406575.8827 | 1384.31 |
| 51 | 642.6 | 172.7 | 15.2 | 84579.1 | 470.78 | 171.84 | 150.54 | 0.176 | 0.032 | 0.089 | 0.5573 | 3.83 | 3.72 | 42.17 | 11.33 | 0.37 | 358588.5437 | 985.55 |
| 52 | 480.1 | 163.1 | 15.2 | 58064.3 | 277.45 | 202.66 | -40.98 | 0.187 | 0.055 | 0.075 | 0.5954 | 3.12 | 2.94 | 31.50 | 10.70 | 1.37 | 253055.2078 | 401.54 |
| 53 | 484.1 | 205.3 | 15.2 | 75567.8 | 330.56 | 153.58 | -25.37 | 0.148 | 0.046 | 0.099 | 0.6575 | 2.44 | 2.36 | 31.77 | 13.47 | 2.15 | 321125.4412 | 401.54 |

# Tobacco Plains/Stillwater Valley Data – Drumlin Delineation Definition #1

| Drum_ID | DL (m) | DW (m) | DH (m) | $DA_b$ (m$^2$) | $DL_f$ | $DL_{sl}$ | DO | $DS_l$ | $DS_f$ | $DS_{sl}$ | DCR | K | L/W | L/H | W/H | L/S | DV (m$^3$) | DNN (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 54 | 340.1 | 123.4 | 21.3 | 32615.4 | 182.02 | 158.12 | 64.63 | 0.346 | 0.117 | 0.135 | 0.6738 | 2.79 | 2.76 | 15.94 | 5.79 | 0.87 | 189923.69 | 462.75 |
| 55 | 574.2 | 136.4 | 21.3 | 60311.9 | 288.74 | 285.45 | 60.91 | 0.313 | 0.074 | 0.075 | 0.5258 | 4.29 | 4.21 | 26.91 | 6.39 | 0.99 | 354360.89 | 188.81 |
| 56 | 504.8 | 163.1 | 21.3 | 60831.9 | 268.08 | 236.72 | 62.20 | 0.262 | 0.080 | 0.090 | 0.5803 | 3.29 | 3.09 | 23.66 | 7.65 | 0.88 | 372489.97 | 188.81 |
| 57 | 507.5 | 158.0 | 13.4 | 63976.0 | 328.09 | 179.40 | 44.39 | 0.170 | 0.041 | 0.075 | 0.6135 | 3.16 | 3.21 | 37.84 | 11.78 | 0.55 | 227976.6 | 1508.40 |
| 58 | 743.1 | 238.5 | 24.1 | 121670.0 | 478.58 | 264.52 | 57.81 | 0.202 | 0.050 | 0.091 | 0.5906 | 3.56 | 3.12 | 30.86 | 9.90 | 0.55 | 904644.07 | 448.12 |
| 59 | 487.9 | 214.0 | 18.3 | 69107.1 | 347.64 | 140.27 | 61.28 | 0.171 | 0.053 | 0.130 | 0.6221 | 2.71 | 2.28 | 26.68 | 11.70 | 0.40 | 404844.82 | 448.12 |
| 60 | 612.8 | 236.7 | 42.7 | 101161.0 | 336.50 | 276.33 | 68.56 | 0.361 | 0.127 | 0.154 | 0.6281 | 2.92 | 2.59 | 14.36 | 5.55 | 0.82 | 1311980.4 | 480.37 |
| 61 | 687.4 | 177.5 | 18.3 | 95200.3 | 409.99 | 277.44 | 68.48 | 0.206 | 0.045 | 0.066 | 0.5831 | 3.90 | 3.87 | 37.59 | 9.71 | 0.68 | 473116.39 | 480.37 |
| 62 | 329.2 | 110.2 | 18.3 | 28202.4 | 220.28 | 108.91 | 65.65 | 0.332 | 0.083 | 0.168 | 0.5805 | 3.02 | 2.99 | 18.00 | 6.03 | 0.49 | 140680.83 | 729.63 |
| 63 | 667.1 | 218.5 | 18.3 | 108918.0 | 379.13 | 288.00 | 65.16 | 0.167 | 0.048 | 0.064 | 0.5884 | 3.21 | 3.05 | 36.48 | 11.95 | 0.76 | 565119.45 | 516.21 |
| 64 | 795.1 | 299.8 | 21.3 | 181018.0 | 453.65 | 341.42 | 65.46 | 0.142 | 0.047 | 0.062 | 0.6298 | 2.74 | 2.65 | 37.26 | 14.05 | 0.75 | 1078348.5 | 516.21 |
| 65 | 717.0 | 170.3 | 15.2 | 96050.9 | 541.20 | 175.75 | 74.17 | 0.179 | 0.028 | 0.087 | 0.5238 | 4.20 | 4.21 | 47.04 | 11.17 | 0.32 | 394476.31 | 511.00 |
| 66 | 311.4 | 166.4 | 15.2 | 37114.4 | 165.54 | 145.85 | 38.27 | 0.183 | 0.092 | 0.104 | 0.7179 | 2.05 | 1.87 | 20.43 | 10.92 | 0.88 | 167365.6 | 697.35 |
| 67 | 492.4 | 175.3 | 15.8 | 66142.5 | 281.24 | 211.19 | 48.10 | 0.181 | 0.056 | 0.075 | 0.6181 | 2.88 | 2.81 | 31.07 | 11.06 | 0.75 | 290084.45 | 286.31 |
| 68 | 440.7 | 145.7 | 15.2 | 44082.0 | 240.66 | 200.03 | 52.70 | 0.209 | 0.063 | 0.076 | 0.6139 | 3.46 | 3.02 | 28.92 | 9.56 | 0.83 | 207469.91 | 286.31 |
| 69 | 397.2 | 150.2 | 27.4 | 34147.2 | 265.46 | 131.73 | 69.14 | 0.365 | 0.103 | 0.208 | 0.6149 | 3.63 | 2.64 | 14.48 | 5.48 | 0.50 | 347015.04 | 619.96 |
| 70 | 352.9 | 114.0 | 13.7 | 29643.2 | 213.01 | 139.86 | 47.16 | 0.241 | 0.064 | 0.098 | 0.5989 | 3.30 | 3.10 | 25.73 | 8.31 | 0.66 | 116982.55 | 619.96 |
| 71 | 380.9 | 179.8 | 15.2 | 46802.7 | 199.50 | 181.39 | 58.67 | 0.170 | 0.076 | 0.084 | 0.7101 | 2.43 | 2.12 | 24.99 | 11.80 | 0.91 | 221258.02 | 346.49 |
| 72 | 516.7 | 265.6 | 12.8 | 96067.7 | 342.02 | 174.63 | 62.72 | 0.096 | 0.037 | 0.073 | 0.7265 | 2.18 | 1.95 | 40.36 | 20.74 | 0.51 | 372367.59 | 309.23 |
| 73 | 554.7 | 116.6 | 15.2 | 48811.8 | 289.56 | 265.13 | 59.08 | 0.261 | 0.053 | 0.057 | 0.5056 | 4.95 | 4.76 | 36.40 | 7.65 | 0.92 | 208933.26 | 273.50 |
| 74 | 596.8 | 189.0 | 51.8 | 78787.1 | 412.83 | 183.98 | 59.84 | 0.548 | 0.126 | 0.282 | 0.5635 | 3.55 | 3.16 | 11.52 | 3.65 | 0.45 | 1239144.3 | 273.50 |
| 75 | 655.2 | 191.2 | 15.2 | 87675.4 | 380.39 | 274.83 | 49.94 | 0.159 | 0.040 | 0.055 | 0.5427 | 3.85 | 3.43 | 42.99 | 12.54 | 0.72 | 404730.1 | 495.08 |
| 76 | 430.6 | 159.4 | 27.4 | 50733.2 | 241.08 | 189.48 | 60.37 | 0.344 | 0.114 | 0.145 | 0.6259 | 2.87 | 2.70 | 15.70 | 5.81 | 0.79 | 399249.78 | 877.91 |
| 77 | 658.1 | 347.9 | 33.5 | 180399.0 | 355.83 | 302.31 | 52.33 | 0.193 | 0.094 | 0.111 | 0.6928 | 1.89 | 1.89 | 19.63 | 10.38 | 0.85 | 1627389.3 | 707.48 |
| 78 | 540.4 | 135.8 | 15.2 | 55774.2 | 296.36 | 244.07 | 63.04 | 0.224 | 0.051 | 0.062 | 0.5496 | 4.11 | 3.98 | 35.46 | 8.91 | 0.82 | 237182.39 | 888.05 |
| 79 | 577.1 | 220.1 | 15.2 | 91855.7 | 347.20 | 229.85 | 58.66 | 0.138 | 0.044 | 0.066 | 0.6393 | 2.85 | 2.62 | 37.86 | 14.44 | 0.66 | 410361.13 | 739.54 |
| 80 | 643.5 | 285.5 | 21.3 | 154395.0 | 356.66 | 286.86 | 67.31 | 0.149 | 0.060 | 0.074 | 0.6642 | 2.11 | 2.25 | 30.16 | 13.38 | 0.80 | 831038.43 | 695.10 |
| 81 | 448.3 | 141.2 | 15.2 | 41859.1 | 251.70 | 196.62 | 63.34 | 0.216 | 0.061 | 0.078 | 0.5662 | 3.77 | 3.18 | 29.42 | 9.26 | 0.78 | 204524.02 | 203.11 |
| 82 | 494.0 | 166.4 | 21.3 | 59278.9 | 254.00 | 240.03 | 61.61 | 0.256 | 0.084 | 0.089 | 0.6213 | 3.23 | 2.97 | 23.15 | 7.80 | 0.94 | 371799.98 | 197.87 |
| 83 | 495.4 | 198.8 | 15.2 | 72546.5 | 251.10 | 244.26 | 69.96 | 0.153 | 0.061 | 0.062 | 0.6850 | 2.66 | 2.49 | 32.50 | 13.04 | 0.97 | 318146.8 | 197.87 |
| 84 | 531.5 | 178.2 | 12.8 | 68843.0 | 363.71 | 167.83 | 72.54 | 0.144 | 0.035 | 0.076 | 0.6181 | 3.22 | 2.98 | 41.52 | 13.92 | 0.46 | 257082 | 890.47 |
| 85 | 622.9 | 283.4 | 13.4 | 117782.0 | 366.73 | 256.21 | 49.58 | 0.095 | 0.037 | 0.052 | 0.6594 | 2.59 | 2.20 | 46.45 | 21.13 | 0.70 | 501928.47 | 1727.83 |
| 86 | 706.0 | 130.6 | 15.2 | 75154.8 | 516.09 | 189.87 | 64.21 | 0.233 | 0.030 | 0.080 | 0.4952 | 5.21 | 5.40 | 46.32 | 8.57 | 0.37 | 297989.45 | 1401.70 |
| 87 | 557.6 | 150.6 | 25.6 | 61993.6 | 322.86 | 234.73 | 60.61 | 0.340 | 0.079 | 0.109 | 0.5622 | 3.94 | 3.70 | 21.78 | 5.88 | 0.73 | 455650.11 | 598.38 |
| 88 | 658.7 | 203.2 | 15.2 | 98482.5 | 335.52 | 323.20 | 60.92 | 0.150 | 0.045 | 0.047 | 0.5582 | 3.46 | 3.24 | 43.22 | 13.33 | 0.96 | 432456.94 | 462.63 |
| 89 | 655.2 | 193.4 | 13.7 | 98855.8 | 348.76 | 306.48 | 84.08 | 0.142 | 0.039 | 0.045 | 0.5942 | 3.41 | 3.39 | 47.77 | 14.10 | 0.88 | 368481.18 | 220.23 |
| 90 | 477.6 | 173.8 | 21.3 | 66229.4 | 287.50 | 190.09 | 48.79 | 0.246 | 0.074 | 0.112 | 0.6353 | 2.70 | 2.75 | 22.38 | 8.14 | 0.66 | 375419.28 | 220.23 |
| 91 | 721.4 | 177.1 | 21.3 | 95190.3 | 377.15 | 344.22 | 59.74 | 0.241 | 0.057 | 0.062 | 0.5140 | 4.29 | 4.07 | 33.81 | 8.30 | 0.91 | 577876.92 | 525.24 |
| 92 | 544.9 | 215.4 | 15.2 | 80259.9 | 326.12 | 218.80 | 50.41 | 0.141 | 0.047 | 0.070 | 0.6395 | 2.91 | 2.53 | 35.76 | 14.14 | 0.67 | 379266.19 | 530.85 |
| 93 | 542.6 | 152.0 | 21.3 | 65633.8 | 375.77 | 166.84 | 61.06 | 0.281 | 0.057 | 0.128 | 0.5570 | 3.52 | 3.57 | 25.43 | 7.12 | 0.44 | 373062.36 | 355.89 |
| 94 | 785.1 | 262.1 | 33.5 | 159998.0 | 445.65 | 339.49 | 65.99 | 0.256 | 0.075 | 0.099 | 0.6275 | 3.03 | 3.00 | 23.42 | 7.82 | 0.76 | 1462494.8 | 355.89 |
| 95 | 552.7 | 241.6 | 21.3 | 93960.9 | 295.22 | 257.44 | 58.83 | 0.177 | 0.072 | 0.083 | 0.6565 | 2.55 | 2.29 | 25.90 | 11.32 | 0.87 | 604031.44 | 800.89 |
| 96 | 668.3 | 173.6 | 15.2 | 87282.7 | 466.24 | 202.07 | 48.37 | 0.176 | 0.033 | 0.075 | 0.5539 | 4.02 | 3.85 | 43.85 | 11.39 | 0.43 | 374914 | 1628.96 |
| 97 | 695.5 | 160.1 | 33.5 | 89435.7 | 359.51 | 335.99 | 59.55 | 0.419 | 0.093 | 0.100 | 0.5398 | 4.25 | 4.35 | 20.74 | 4.77 | 0.93 | 791287.45 | 1016.65 |
| 98 | 334.3 | 136.5 | 21.3 | 34974.0 | 225.48 | 108.84 | 62.47 | 0.313 | 0.095 | 0.196 | 0.6168 | 2.51 | 2.45 | 15.67 | 6.40 | 0.48 | 206434.89 | 436.96 |
| 99 | 474.1 | 196.2 | 15.2 | 77474.1 | 291.58 | 182.55 | 64.81 | 0.155 | 0.052 | 0.083 | 0.6322 | 2.28 | 2.42 | 31.11 | 12.88 | 0.63 | 300629.11 | 269.86 |
| 100 | 904.2 | 254.6 | 31.7 | 173494.0 | 598.24 | 306.00 | 61.38 | 0.249 | 0.053 | 0.104 | 0.5458 | 3.70 | 3.55 | 28.53 | 8.03 | 0.51 | 1546880.4 | 269.86 |
| 101 | 668.5 | 171.5 | 15.2 | 84478.6 | 393.78 | 274.76 | 60.22 | 0.178 | 0.039 | 0.055 | 0.5342 | 4.16 | 3.90 | 43.87 | 11.25 | 0.70 | 370484.4 | 403.23 |
| 102 | 382.2 | 110.0 | 21.3 | 38087.2 | 198.90 | 183.25 | 54.84 | 0.388 | 0.107 | 0.116 | 0.6228 | 3.01 | 3.48 | 17.91 | 5.15 | 0.92 | 190080.58 | 846.36 |
| 103 | 644.5 | 239.4 | 27.4 | 104699.0 | 381.72 | 262.82 | 55.58 | 0.229 | 0.072 | 0.104 | 0.6131 | 3.12 | 2.69 | 23.50 | 8.73 | 0.69 | 897284.4 | 307.13 |
| 104 | 262.3 | 70.8 | 15.2 | 14453.8 | 137.97 | 124.35 | 45.53 | 0.431 | 0.110 | 0.123 | 0.5454 | 3.74 | 3.71 | 17.21 | 4.65 | 0.90 | 60003.162 | 307.13 |
| 105 | 374.7 | 93.4 | 15.2 | 25003.2 | 191.64 | 183.01 | 56.55 | 0.326 | 0.080 | 0.083 | 0.5210 | 4.41 | 4.01 | 24.58 | 6.13 | 0.95 | 113049.08 | 341.97 |
| 106 | 882.4 | 263.4 | 33.5 | 180034.0 | 492.63 | 389.75 | 51.06 | 0.255 | 0.068 | 0.086 | 0.5953 | 3.40 | 3.35 | 26.32 | 7.86 | 0.79 | 1652173.9 | 436.98 |
| 107 | 579.2 | 149.0 | 15.2 | 75344.5 | 308.07 | 271.09 | 49.14 | 0.205 | 0.049 | 0.056 | 0.5635 | 3.50 | 3.89 | 38.00 | 9.78 | 0.88 | 278796.48 | 230.25 |
| 108 | 606.4 | 134.1 | 15.2 | 63079.9 | 340.48 | 265.90 | 50.51 | 0.227 | 0.045 | 0.057 | 0.5293 | 4.58 | 4.52 | 39.79 | 8.80 | 0.78 | 262678.33 | 230.25 |
| 109 | 655.5 | 191.3 | 15.2 | 103846.0 | 368.61 | 286.91 | 57.50 | 0.159 | 0.041 | 0.053 | 0.5991 | 3.25 | 3.43 | 43.01 | 12.55 | 0.78 | 405086.08 | 355.29 |
| 110 | 905.3 | 323.5 | 21.3 | 204770.0 | 489.01 | 416.28 | 53.18 | 0.132 | 0.044 | 0.051 | 0.6238 | 3.14 | 2.80 | 42.43 | 15.16 | 0.85 | 1324786.3 | 355.29 |
| 111 | 930.1 | 195.8 | 21.3 | 154455.0 | 511.13 | 418.95 | 44.04 | 0.218 | 0.042 | 0.051 | 0.5166 | 4.40 | 4.75 | 43.59 | 9.18 | 1.22 | 823725.66 | 507.64 |
| 112 | 929.4 | 87.2 | 21.3 | 60523.1 | 695.50 | 233.95 | 62.87 | 0.489 | 0.031 | 0.091 | 0.3402 | 11.21 | 10.65 | 43.56 | 4.09 | 2.97 | 366748.63 | 507.64 |

# Tobacco Plains/Stillwater Valley Data – Drumlin Delineation Definition #1

| Drum_ID | DL (m) | DW (m) | DH (m) | $DA_b$ ($m^2$) | $DL_q$ | $DL_{sl}$ | DO | $DS_i$ | $DS_s$ | $DS_{sl}$ | DCR | K | L/W | L/H | W/H | L/S | DV ($m^3$) | DNN (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 113 | 423.46 | 167.21 | 21.34 | 57170.20 | 229.68 | 193.78 | 51.67 | 0.255 | 0.093 | 0.110 | 0.6068 | 2.46 | 2.53 | 19.85 | 7.84 | 0.84 | 320282.1144 | 1341.42 |
| 114 | 886.70 | 167.68 | 15.24 | 112821.00 | 649.26 | 237.45 | 46.82 | 0.182 | 0.023 | 0.064 | 0.4833 | 5.47 | 5.29 | 58.18 | 11.00 | 0.37 | 480373.8093 | 1215.51 |
| 115 | 345.17 | 100.59 | 15.24 | 26939.60 | 220.76 | 124.41 | 68.28 | 0.303 | 0.069 | 0.122 | 0.5898 | 3.47 | 3.43 | 22.65 | 6.60 | 0.56 | 112173.8257 | 501.48 |
| 116 | 617.59 | 151.89 | 21.34 | 72825.50 | 320.44 | 297.15 | 47.38 | 0.281 | 0.067 | 0.072 | 0.5432 | 4.11 | 4.07 | 28.95 | 7.12 | 0.93 | 424319.4947 | 501.48 |
| 117 | 472.51 | 181.40 | 15.24 | 64522.30 | 262.43 | 210.09 | 53.73 | 0.168 | 0.058 | 0.073 | 0.6223 | 2.72 | 2.60 | 31.00 | 11.90 | 0.80 | 276936.433 | 409.26 |
| 118 | 642.98 | 120.49 | 15.24 | 63891.70 | 364.36 | 278.62 | 60.30 | 0.253 | 0.042 | 0.055 | 0.4852 | 5.08 | 5.34 | 42.19 | 7.91 | 0.76 | 250316.0736 | 409.26 |
| 119 | 552.15 | 150.83 | 15.24 | 70612.00 | 302.92 | 249.23 | 55.08 | 0.202 | 0.050 | 0.061 | 0.5760 | 3.39 | 3.66 | 36.23 | 9.90 | 0.82 | 269064.8324 | 414.87 |
| 120 | 882.24 | 342.16 | 13.41 | 224106.00 | 525.49 | 356.75 | 57.32 | 0.078 | 0.026 | 0.038 | 0.6117 | 2.73 | 2.58 | 65.78 | 25.51 | 0.68 | 858272.468 | 1178.45 |
| 121 | 723.63 | 249.50 | 15.24 | 156184.00 | 373.99 | 349.64 | 58.54 | 0.122 | 0.041 | 0.044 | 0.6012 | 2.63 | 2.90 | 47.48 | 16.37 | 0.93 | 583340.0621 | 409.67 |
| 122 | 415.08 | 202.72 | 15.24 | 63370.20 | 252.00 | 163.09 | 55.48 | 0.150 | 0.060 | 0.093 | 0.6836 | 2.14 | 2.05 | 27.24 | 13.30 | 0.65 | 271865.9599 | 409.67 |
| 123 | 449.20 | 171.04 | 15.24 | 55236.90 | 256.37 | 192.84 | 53.63 | 0.178 | 0.059 | 0.079 | 0.6241 | 2.87 | 2.63 | 29.47 | 11.22 | 0.75 | 248233.3981 | 505.80 |
| 124 | 451.56 | 135.26 | 15.24 | 42128.60 | 280.66 | 170.91 | 78.42 | 0.225 | 0.054 | 0.089 | 0.5662 | 3.80 | 3.34 | 29.63 | 8.87 | 0.61 | 197331.8757 | 505.80 |
| 125 | 1165.28 | 194.73 | 21.34 | 156613.00 | 826.19 | 339.10 | 67.62 | 0.219 | 0.026 | 0.063 | 0.4292 | 6.81 | 5.98 | 54.61 | 9.13 | 0.41 | 1026419.318 | 1159.98 |
| 126 | 748.85 | 352.59 | 21.34 | 202354.00 | 419.35 | 329.51 | 72.67 | 0.121 | 0.051 | 0.065 | 0.6632 | 2.18 | 2.12 | 35.10 | 16.53 | 0.79 | 1194320.687 | 996.96 |
| 127 | 524.38 | 165.49 | 15.24 | 61060.50 | 294.18 | 230.19 | 68.72 | 0.184 | 0.052 | 0.066 | 0.5538 | 3.54 | 3.17 | 34.41 | 10.86 | 0.78 | 280382.4062 | 247.87 |
| 128 | 510.97 | 229.49 | 27.43 | 97155.30 | 258.00 | 252.97 | 65.93 | 0.239 | 0.106 | 0.108 | 0.6410 | 2.11 | 2.23 | 18.63 | 8.37 | 0.98 | 681938.5456 | 247.87 |
| 129 | 1081.71 | 245.67 | 39.62 | 212216.00 | 665.97 | 415.74 | 60.03 | 0.323 | 0.059 | 0.095 | 0.5236 | 4.33 | 4.40 | 27.30 | 6.20 | 0.62 | 2232369.92 | 479.01 |
| 130 | 423.46 | 154.17 | 15.24 | 50791.50 | 232.57 | 190.89 | 65.81 | 0.198 | 0.066 | 0.080 | 0.6316 | 2.77 | 2.75 | 27.79 | 10.12 | 0.82 | 210934.6902 | 506.73 |
| 131 | 690.40 | 202.41 | 30.48 | 110522.00 | 368.25 | 322.14 | 52.59 | 0.301 | 0.083 | 0.095 | 0.5734 | 3.39 | 3.41 | 22.65 | 6.64 | 0.87 | 902983.2375 | 506.73 |
| 132 | 943.78 | 269.48 | 21.34 | 166539.00 | 716.47 | 227.31 | 68.95 | 0.158 | 0.030 | 0.094 | 0.5357 | 4.20 | 3.50 | 44.23 | 12.63 | 0.32 | 1150401.702 | 866.46 |
| 133 | 752.90 | 248.32 | 30.48 | 141026.00 | 465.94 | 286.96 | 46.92 | 0.245 | 0.065 | 0.106 | 0.6366 | 3.16 | 3.03 | 24.70 | 8.15 | 0.62 | 1208089.578 | 1159.98 |
| 134 | 1005.31 | 144.00 | 18.29 | 107606.00 | 763.48 | 241.83 | 66.32 | 0.254 | 0.024 | 0.076 | 0.4221 | 7.38 | 6.98 | 54.97 | 7.87 | 0.32 | 561255.0611 | 679.07 |
| 135 | 909.29 | 240.69 | 18.29 | 131807.00 | 491.95 | 417.34 | 60.78 | 0.152 | 0.037 | 0.044 | 0.5082 | 4.93 | 3.78 | 49.72 | 13.16 | 0.85 | 848537.2145 | 679.07 |
| 136 | 1433.46 | 215.88 | 18.29 | 210199.00 | 908.40 | 525.06 | 58.29 | 0.169 | 0.020 | 0.035 | 0.4171 | 7.68 | 6.64 | 78.38 | 11.80 | 0.58 | 1199794.38 | 591.95 |
| 137 | 856.93 | 212.17 | 18.29 | 145594.00 | 466.45 | 390.47 | 53.30 | 0.172 | 0.039 | 0.047 | 0.5485 | 3.96 | 4.04 | 46.86 | 11.60 | 0.84 | 704897.4379 | 1104.72 |
| 138 | 370.09 | 169.69 | 15.85 | 44634.80 | 213.94 | 156.14 | 65.47 | 0.187 | 0.074 | 0.102 | 0.6893 | 2.41 | 2.18 | 23.35 | 10.71 | 0.73 | 211019.9228 | 1158.97 |
| 139 | 509.28 | 266.82 | 30.48 | 96856.40 | 276.27 | 233.01 | 42.54 | 0.228 | 0.110 | 0.131 | 0.7085 | 2.10 | 1.91 | 16.71 | 8.75 | 0.84 | 878070.1212 | 1239.99 |
| 140 | 567.43 | 167.45 | 13.72 | 74094.50 | 347.73 | 219.70 | 69.12 | 0.164 | 0.039 | 0.062 | 0.5981 | 3.41 | 3.39 | 41.37 | 12.21 | 0.63 | 276280.5552 | 1116.74 |
| 141 | 630.93 | 246.42 | 19.81 | 117345.00 | 352.72 | 278.21 | 75.82 | 0.161 | 0.056 | 0.071 | 0.6388 | 2.66 | 2.56 | 31.85 | 12.44 | 0.79 | 653022.9569 | 696.81 |
| 142 | 566.42 | 148.74 | 19.81 | 66812.80 | 300.45 | 265.97 | 68.51 | 0.266 | 0.066 | 0.074 | 0.5647 | 3.77 | 3.81 | 28.59 | 7.51 | 0.89 | 353864.6836 | 696.81 |
| 143 | 794.03 | 108.63 | 18.29 | 60212.40 | 499.52 | 294.51 | 67.05 | 0.337 | 0.037 | 0.062 | 0.3802 | 8.22 | 7.31 | 43.42 | 5.94 | 0.59 | 334426.7151 | 749.09 |
| 144 | 556.33 | 120.91 | 14.33 | 48196.00 | 287.97 | 268.36 | 68.16 | 0.237 | 0.050 | 0.053 | 0.5310 | 5.04 | 4.60 | 38.83 | 8.44 | 0.93 | 204288.0874 | 749.09 |
| 145 | 726.66 | 258.77 | 20.12 | 140211.00 | 402.93 | 323.73 | 70.83 | 0.155 | 0.050 | 0.062 | 0.5807 | 2.96 | 2.81 | 36.12 | 12.86 | 0.80 | 801946.392 | 806.10 |
| 146 | 943.63 | 295.43 | 42.67 | 191794.00 | 567.12 | 376.50 | 76.00 | 0.289 | 0.075 | 0.113 | 0.6016 | 3.65 | 3.19 | 22.11 | 6.92 | 0.66 | 2521975.835 | 806.10 |
| 147 | 1336.44 | 280.07 | 18.29 | 285688.00 | 688.56 | 647.88 | 65.02 | 0.131 | 0.027 | 0.028 | 0.5056 | 4.91 | 4.77 | 73.08 | 15.31 | 0.94 | 1451159.426 | 591.95 |

# Tobacco Plains/Stillwater Valley Data – Drumlin Delineation Definition #2

| Drum_ID | DL (m) | DW (m) | DH (m) | DA$_b$ (m$^2$) | DL$_a$ | DL$_{sl}$ | DO | DS$_i$ | DS$_f$ | DS$_{sl}$ | DCR | K | L/W | L/H | W/H | L/S | DV (m$^3$) | DNN (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Min | 171.19 | 64.08 | 7.01 | 12936.00 | 98.52 | 72.67 | 23.68 | 0.08 | 0.02 | 0.03 | 0.34 | 1.73 | 1.69 | 11.23 | 3.65 | 0.32 | 30893.06 | 140.32 |
| Max | 1433.46 | 422.38 | 51.82 | 355242.00 | 908.40 | 647.88 | 98.69 | 0.55 | 0.15 | 0.28 | 0.78 | 11.21 | 10.65 | 83.00 | 25.51 | 1.02 | 5008882.79 | 2102.30 |
| Range | 1262.27 | 358.31 | 44.81 | 342306.00 | 809.87 | 575.21 | 75.00 | 0.47 | 0.14 | 0.25 | 0.44 | 9.48 | 8.97 | 71.77 | 21.86 | 0.70 | 4977989.72 | 1961.98 |
| Average (μ) | 602.63 | 190.41 | 18.49 | 92921.68 | 356.71 | 245.92 | 62.72 | 0.20 | 0.06 | 0.08 | 0.59 | 3.53 | 3.36 | 35.46 | 11.12 | 0.73 | 564031.68 | 624.11 |
| STDEV (σ) | 217.21 | 70.08 | 7.98 | 63210.90 | 147.40 | 88.72 | 11.24 | 0.08 | 0.02 | 0.04 | 0.07 | 1.34 | 1.25 | 13.06 | 4.02 | 0.18 | 624977.77 | 357.97 |
| Skewness | 0.97 | 0.79 | 1.63 | 1.60 | 1.14 | 1.22 | 0.45 | 1.26 | 1.27 | 1.98 | -0.37 | 2.05 | 2.01 | 0.94 | 0.89 | -0.51 | 3.22 | 1.24 |
| Kurtosis | 1.25 | 0.30 | 3.76 | 2.81 | 1.42 | 2.70 | 1.17 | 2.44 | 2.13 | 6.41 | 0.59 | 7.08 | 7.05 | 1.51 | 0.93 | -0.67 | 15.75 | 1.57 |
| Coefficient of Variance (CV) | 36.04 | 36.80 | 43.16 | 68.03 | 41.32 | 36.08 | 17.92 | 37.94 | 40.98 | 45.24 | 12.59 | 38.03 | 37.10 | 36.82 | 36.11 | 24.53 | 110.81 | 57.36 |
| 1 | 1172.12 | 328.33 | 30.79 | 310389.00 | 772.78 | 399.35 | 82.78 | 0.188 | 0.040 | 0.077 | 0.6079 | 3.48 | 3.57 | 38.07 | 10.67 | 0.52 | 2511673.18 | 362.66 |
| 2 | 715.21 | 125.04 | 15.24 | 66954.90 | 393.00 | 322.21 | 82.44 | 0.244 | 0.039 | 0.047 | 0.5184 | 6.00 | 5.72 | 46.93 | 8.20 | 0.82 | 288933.31 | 362.66 |
| 3 | 818.23 | 194.18 | 15.24 | 130036.00 | 415.64 | 402.59 | 85.00 | 0.157 | 0.037 | 0.038 | 0.6035 | 4.04 | 4.21 | 53.69 | 12.74 | 0.97 | 513329.73 | 1609.67 |
| 4 | 381.31 | 149.22 | 15.24 | 44332.70 | 203.57 | 177.74 | 86.95 | 0.204 | 0.075 | 0.086 | 0.7298 | 2.58 | 2.56 | 25.02 | 9.79 | 0.87 | 183833.56 | 276.31 |
| 5 | 171.19 | 94.38 | 15.24 | 12936.00 | 98.52 | 72.67 | 70.33 | 0.323 | 0.155 | 0.210 | 0.6864 | 1.78 | 1.81 | 11.23 | 6.19 | 0.74 | 52204.11 | 276.31 |
| 6 | 644.79 | 266.83 | 21.34 | 129842.00 | 413.76 | 231.03 | 66.57 | 0.160 | 0.052 | 0.092 | 0.6624 | 2.51 | 2.42 | 30.22 | 12.51 | 0.56 | 778218.75 | 583.94 |
| 7 | 457.16 | 227.03 | 15.24 | 84604.60 | 232.53 | 224.63 | 82.71 | 0.134 | 0.066 | 0.068 | 0.7351 | 1.94 | 2.01 | 30.00 | 14.90 | 0.97 | 335337.28 | 740.31 |
| 8 | 840.94 | 139.23 | 15.24 | 80814.60 | 508.78 | 332.16 | 83.48 | 0.219 | 0.030 | 0.046 | 0.5067 | 6.87 | 6.04 | 55.18 | 9.14 | 0.65 | 378296.37 | 740.31 |
| 9 | 527.70 | 173.22 | 15.24 | 73339.70 | 276.27 | 251.43 | 97.80 | 0.176 | 0.055 | 0.061 | 0.6728 | 2.98 | 3.05 | 34.63 | 11.37 | 0.91 | 295327.11 | 1055.84 |
| 10 | 578.40 | 197.65 | 15.24 | 90115.70 | 362.45 | 215.95 | 72.00 | 0.154 | 0.042 | 0.071 | 0.6298 | 2.92 | 2.93 | 37.95 | 12.97 | 0.60 | 369360.18 | 333.44 |
| 11 | 310.10 | 182.04 | 15.24 | 43231.80 | 180.78 | 129.32 | 63.31 | 0.167 | 0.084 | 0.118 | 0.7223 | 1.75 | 1.70 | 20.35 | 11.94 | 0.72 | 182389.94 | 333.44 |
| 12 | 684.98 | 318.84 | 15.24 | 161733.00 | 395.30 | 289.67 | 23.68 | 0.096 | 0.039 | 0.053 | 0.6955 | 2.28 | 2.15 | 44.95 | 20.92 | 0.73 | 705634.00 | 764.90 |
| 13 | 486.01 | 272.19 | 15.24 | 101417.00 | 266.09 | 219.91 | 54.85 | 0.112 | 0.057 | 0.069 | 0.7182 | 1.83 | 1.79 | 31.89 | 17.86 | 0.83 | 427405.02 | 764.90 |
| 14 | 334.96 | 181.28 | 15.24 | 50064.60 | 179.64 | 155.33 | 68.12 | 0.168 | 0.085 | 0.098 | 0.6855 | 1.76 | 1.85 | 21.98 | 11.89 | 0.86 | 196187.78 | 2102.30 |
| 15 | 1153.36 | 350.72 | 16.76 | 315915.00 | 612.04 | 541.32 | 73.02 | 0.096 | 0.027 | 0.031 | 0.5534 | 3.31 | 3.29 | 68.80 | 20.92 | 0.88 | 1437620.02 | 1295.59 |
| 16 | 1091.69 | 272.97 | 27.43 | 227029.00 | 567.29 | 524.40 | 72.54 | 0.201 | 0.048 | 0.052 | 0.5719 | 4.12 | 4.00 | 39.80 | 9.95 | 0.92 | 1733074.00 | 1295.59 |
| 17 | 433.89 | 210.63 | 21.34 | 64945.90 | 246.55 | 187.33 | 83.19 | 0.203 | 0.087 | 0.114 | 0.6789 | 2.28 | 2.06 | 20.34 | 9.87 | 0.76 | 413382.32 | 1048.32 |
| 18 | 609.69 | 151.72 | 21.34 | 66219.50 | 323.62 | 286.07 | 74.89 | 0.281 | 0.066 | 0.075 | 0.5186 | 4.41 | 4.02 | 28.58 | 7.11 | 0.88 | 418405.68 | 656.12 |
| 19 | 900.36 | 335.99 | 46.64 | 221728.00 | 630.11 | 270.25 | 69.99 | 0.278 | 0.074 | 0.173 | 0.6006 | 2.87 | 2.68 | 19.31 | 7.20 | 0.43 | 2990813.05 | 656.12 |
| 20 | 694.64 | 271.41 | 21.34 | 144865.00 | 427.88 | 266.76 | 63.09 | 0.157 | 0.050 | 0.080 | 0.6553 | 2.62 | 2.56 | 32.56 | 12.72 | 0.62 | 852787.21 | 534.46 |
| 21 | 549.55 | 147.82 | 18.59 | 59900.80 | 288.08 | 261.47 | 69.29 | 0.252 | 0.065 | 0.071 | 0.5760 | 3.96 | 3.72 | 29.56 | 7.95 | 0.91 | 320214.25 | 534.46 |
| 22 | 506.28 | 270.39 | 15.24 | 106715.00 | 286.50 | 219.77 | 67.23 | 0.113 | 0.053 | 0.069 | 0.6667 | 1.89 | 1.87 | 33.22 | 17.74 | 0.77 | 442288.96 | 671.49 |
| 23 | 381.10 | 150.48 | 22.25 | 42889.30 | 240.92 | 140.18 | 73.43 | 0.296 | 0.092 | 0.159 | 0.6395 | 2.66 | 2.53 | 17.13 | 6.76 | 0.58 | 270515.47 | 897.85 |
| 24 | 812.14 | 218.99 | 21.34 | 136145.00 | 464.96 | 347.18 | 68.11 | 0.195 | 0.046 | 0.061 | 0.5622 | 3.80 | 3.71 | 38.06 | 10.26 | 0.75 | 804465.61 | 287.14 |
| 25 | 816.63 | 338.09 | 21.34 | 196924.00 | 421.73 | 394.91 | 64.71 | 0.126 | 0.051 | 0.054 | 0.6726 | 2.66 | 2.42 | 38.27 | 15.85 | 0.94 | 1248872.42 | 287.14 |
| 26 | 966.88 | 255.59 | 33.53 | 200702.00 | 554.37 | 412.51 | 71.25 | 0.262 | 0.060 | 0.081 | 0.5606 | 3.66 | 3.78 | 28.84 | 7.62 | 0.74 | 1756575.12 | 530.30 |
| 27 | 514.63 | 209.36 | 21.34 | 79906.20 | 261.87 | 252.77 | 74.34 | 0.204 | 0.081 | 0.084 | 0.6849 | 2.60 | 2.46 | 24.12 | 9.81 | 0.97 | 487361.60 | 582.60 |
| 28 | 687.79 | 175.01 | 21.34 | 94193.40 | 414.76 | 273.04 | 72.60 | 0.244 | 0.051 | 0.078 | 0.5703 | 3.94 | 3.93 | 32.24 | 8.20 | 0.66 | 544455.70 | 944.91 |
| 29 | 609.05 | 229.44 | 21.34 | 91327.40 | 415.38 | 193.67 | 95.53 | 0.186 | 0.051 | 0.110 | 0.6142 | 3.19 | 2.65 | 28.55 | 10.75 | 0.47 | 632093.15 | 600.30 |
| 30 | 853.49 | 347.78 | 27.43 | 227631.00 | 548.71 | 304.78 | 66.75 | 0.158 | 0.050 | 0.090 | 0.6290 | 2.51 | 2.45 | 31.11 | 12.68 | 0.56 | 1726236.85 | 933.89 |
| 31 | 882.16 | 374.88 | 33.53 | 289032.00 | 461.35 | 420.80 | 49.12 | 0.179 | 0.073 | 0.080 | 0.6207 | 2.11 | 2.35 | 26.31 | 11.18 | 0.91 | 2350616.17 | 933.89 |
| 32 | 1079.52 | 422.38 | 51.82 | 355242.00 | 766.43 | 313.09 | 51.51 | 0.245 | 0.068 | 0.166 | 0.6104 | 2.58 | 2.56 | 20.83 | 8.15 | 0.41 | 5008882.79 | 1158.30 |
| 33 | 514.90 | 172.12 | 15.24 | 59339.60 | 312.49 | 202.42 | 63.83 | 0.177 | 0.049 | 0.075 | 0.5580 | 3.51 | 2.99 | 33.79 | 11.29 | 0.65 | 286344.71 | 687.44 |
| 34 | 374.26 | 164.46 | 15.24 | 49833.90 | 262.34 | 111.92 | 57.70 | 0.185 | 0.058 | 0.136 | 0.6572 | 2.21 | 2.28 | 24.56 | 10.79 | 0.43 | 198871.23 | 701.35 |
| 35 | 652.71 | 167.60 | 21.34 | 86619.20 | 409.64 | 243.08 | 60.44 | 0.255 | 0.052 | 0.088 | 0.5573 | 3.86 | 3.89 | 30.59 | 7.86 | 0.59 | 494826.75 | 701.35 |
| 36 | 553.84 | 139.13 | 21.34 | 64029.10 | 336.25 | 217.59 | 62.82 | 0.307 | 0.063 | 0.098 | 0.5531 | 3.76 | 3.98 | 25.96 | 6.52 | 0.65 | 348537.20 | 1190.06 |
| 37 | 560.47 | 153.78 | 15.24 | 62928.60 | 346.09 | 214.39 | 66.76 | 0.198 | 0.044 | 0.071 | 0.5704 | 3.92 | 3.64 | 36.78 | 10.09 | 0.62 | 278475.65 | 1170.17 |
| 38 | 637.94 | 335.22 | 27.43 | 155112.00 | 413.32 | 224.62 | 56.76 | 0.164 | 0.066 | 0.122 | 0.6661 | 2.06 | 1.90 | 23.25 | 12.22 | 0.54 | 1243669.88 | 687.44 |
| 39 | 909.38 | 237.72 | 15.24 | 147061.00 | 637.33 | 272.04 | 53.84 | 0.128 | 0.024 | 0.056 | 0.5230 | 4.42 | 3.83 | 59.67 | 15.60 | 0.43 | 698435.98 | 509.16 |
| 40 | 640.96 | 168.21 | 21.34 | 87119.80 | 343.76 | 297.20 | 55.43 | 0.254 | 0.062 | 0.072 | 0.5602 | 3.70 | 3.81 | 30.04 | 7.88 | 0.86 | 487676.54 | 509.16 |
| 41 | 825.33 | 192.15 | 27.43 | 104470.00 | 603.13 | 222.20 | 59.77 | 0.286 | 0.045 | 0.123 | 0.4716 | 5.12 | 4.30 | 30.09 | 7.00 | 0.37 | 922264.15 | 689.31 |
| 42 | 817.59 | 124.00 | 21.34 | 80694.60 | 540.01 | 277.58 | 58.08 | 0.344 | 0.040 | 0.077 | 0.4215 | 6.51 | 6.59 | 38.32 | 5.81 | 0.51 | 458579.53 | 229.03 |
| 43 | 478.75 | 169.52 | 15.24 | 65295.20 | 301.49 | 177.26 | 58.53 | 0.180 | 0.051 | 0.086 | 0.6267 | 2.76 | 2.82 | 31.41 | 11.12 | 0.59 | 262207.59 | 229.03 |
| 44 | 592.61 | 192.52 | 15.24 | 73389.70 | 353.69 | 238.92 | 50.81 | 0.158 | 0.043 | 0.064 | 0.5114 | 3.76 | 3.08 | 38.88 | 12.63 | 0.68 | 368607.91 | 403.41 |
| 45 | 685.83 | 297.26 | 21.34 | 153810.00 | 391.59 | 294.24 | 50.02 | 0.144 | 0.054 | 0.073 | 0.6660 | 2.40 | 2.31 | 32.14 | 13.93 | 0.75 | 922179.93 | 650.32 |
| 46 | 532.30 | 178.08 | 15.24 | 74737.70 | 321.72 | 210.58 | 56.27 | 0.171 | 0.047 | 0.072 | 0.5981 | 2.98 | 2.99 | 34.93 | 11.68 | 0.65 | 306258.67 | 534.31 |
| 47 | 488.74 | 123.34 | 15.24 | 47024.30 | 305.80 | 182.94 | 58.98 | 0.247 | 0.050 | 0.083 | 0.5504 | 3.99 | 3.96 | 32.07 | 8.09 | 0.60 | 194757.15 | 421.64 |
| 48 | 779.51 | 355.62 | 21.34 | 223377.00 | 544.02 | 235.49 | 50.22 | 0.120 | 0.039 | 0.091 | 0.6504 | 2.14 | 2.19 | 36.53 | 16.67 | 0.43 | 1253887.63 | 421.64 |
| 49 | 662.04 | 187.62 | 15.24 | 78403.30 | 380.96 | 281.08 | 58.88 | 0.162 | 0.040 | 0.054 | 0.5447 | 4.39 | 3.53 | 43.44 | 12.31 | 0.74 | 401309.71 | 876.21 |
| 50 | 529.47 | 264.08 | 13.72 | 104889.00 | 318.42 | 211.05 | 48.36 | 0.104 | 0.043 | 0.065 | 0.6847 | 2.10 | 2.00 | 38.60 | 19.25 | 0.66 | 406575.88 | 1384.31 |
| 51 | 642.62 | 172.71 | 15.24 | 84579.10 | 470.78 | 171.84 | 60.54 | 0.176 | 0.032 | 0.089 | 0.5573 | 3.83 | 3.72 | 42.17 | 11.33 | 0.37 | 358588.54 | 985.56 |
| 52 | 480.11 | 163.14 | 15.24 | 58064.30 | 277.45 | 202.66 | 62.06 | 0.187 | 0.055 | 0.075 | 0.5954 | 3.12 | 2.94 | 31.50 | 10.70 | 0.73 | 253055.21 | 401.54 |
| 53 | 484.13 | 205.30 | 15.24 | 75567.80 | 330.56 | 153.58 | 49.02 | 0.148 | 0.046 | 0.099 | 0.6575 | 2.44 | 2.36 | 31.77 | 13.47 | 0.46 | 321125.44 | 401.54 |

# Tobacco Plains/Stillwater Valley Data – Drumlin Delineation Definition #2

| Drum_ID | DL (m) | DW (m) | DH (m) | $DA_b$ ($m^2$) | $DL_u$ | $DL_d$ | DO | $DS_l$ | $DS_t$ | $DS_d$ | DCR | K | L/W | L/H | W/H | L/S | DV ($m^3$) | DNN (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 54 | 340.14 | 123.44 | 21.34 | 32615.40 | 182.02 | 158.12 | 64.63 | 0.346 | 0.117 | 0.135 | 0.6738 | 2.79 | 2.76 | 15.94 | 5.79 | 0.87 | 189923.7 | 462.75 |
| 55 | 574.19 | 136.44 | 21.34 | 60311.90 | 288.74 | 285.45 | 60.91 | 0.313 | 0.074 | 0.075 | 0.5258 | 4.29 | 4.21 | 26.91 | 6.39 | 0.99 | 354360.9 | 188.81 |
| 56 | 504.79 | 163.14 | 21.34 | 60831.90 | 268.08 | 236.72 | 62.20 | 0.262 | 0.080 | 0.090 | 0.5803 | 3.29 | 3.09 | 23.66 | 7.65 | 0.88 | 372490.0 | 188.81 |
| 57 | 507.49 | 158.00 | 13.41 | 63976.00 | 328.09 | 179.40 | 44.39 | 0.170 | 0.041 | 0.075 | 0.6135 | 3.16 | 3.21 | 37.84 | 11.78 | 0.55 | 227976.6 | 1508.40 |
| 58 | 743.10 | 238.48 | 24.08 | 121670.00 | 478.58 | 264.52 | 57.81 | 0.202 | 0.050 | 0.091 | 0.5906 | 3.56 | 3.12 | 30.86 | 9.90 | 0.55 | 904644.1 | 448.12 |
| 59 | 487.90 | 214.02 | 18.29 | 69107.10 | 347.64 | 140.27 | 61.28 | 0.171 | 0.053 | 0.130 | 0.6221 | 2.71 | 2.28 | 26.68 | 11.70 | 0.40 | 404844.8 | 448.12 |
| 60 | 612.82 | 236.65 | 42.67 | 101161.00 | 336.50 | 276.33 | 68.56 | 0.361 | 0.127 | 0.154 | 0.6281 | 2.92 | 2.59 | 14.36 | 5.55 | 0.82 | 1311980.4 | 480.37 |
| 61 | 687.43 | 177.51 | 18.29 | 95200.30 | 409.99 | 277.44 | 68.48 | 0.206 | 0.045 | 0.066 | 0.5831 | 3.90 | 3.87 | 37.59 | 9.71 | 0.68 | 473116.4 | 480.37 |
| 62 | 329.20 | 110.22 | 18.29 | 28202.40 | 220.28 | 108.91 | 65.65 | 0.332 | 0.083 | 0.168 | 0.5805 | 3.02 | 2.99 | 18.00 | 6.03 | 0.49 | 140680.8 | 729.63 |
| 63 | 667.13 | 218.49 | 18.29 | 108918.00 | 379.13 | 288.00 | 65.16 | 0.167 | 0.048 | 0.064 | 0.5884 | 3.21 | 3.05 | 36.48 | 11.95 | 0.76 | 565119.5 | 516.21 |
| 64 | 795.07 | 299.85 | 21.34 | 181018.00 | 453.65 | 341.42 | 65.46 | 0.142 | 0.047 | 0.062 | 0.6298 | 2.74 | 2.65 | 37.26 | 14.05 | 0.75 | 1078348.5 | 516.21 |
| 65 | 716.96 | 170.30 | 15.24 | 96050.90 | 541.20 | 175.75 | 74.17 | 0.179 | 0.028 | 0.087 | 0.5238 | 4.20 | 4.21 | 47.04 | 11.17 | 0.32 | 394476.3 | 511.00 |
| 66 | 311.40 | 166.35 | 15.24 | 37114.40 | 165.54 | 145.85 | 38.27 | 0.183 | 0.092 | 0.104 | 0.7179 | 2.05 | 1.87 | 20.43 | 10.92 | 0.88 | 167365.6 | 697.35 |
| 67 | 492.44 | 175.31 | 15.85 | 66142.50 | 281.24 | 211.19 | 48.10 | 0.181 | 0.056 | 0.075 | 0.6181 | 2.88 | 2.81 | 31.07 | 11.06 | 0.75 | 290084.4 | 286.31 |
| 68 | 440.68 | 145.72 | 15.24 | 44082.00 | 240.66 | 200.03 | 52.70 | 0.209 | 0.063 | 0.076 | 0.6139 | 3.46 | 3.02 | 28.92 | 9.56 | 0.83 | 207469.9 | 286.31 |
| 69 | 397.18 | 150.23 | 27.43 | 34147.20 | 265.46 | 131.73 | 69.14 | 0.365 | 0.103 | 0.208 | 0.6149 | 3.63 | 2.64 | 14.48 | 5.48 | 0.50 | 347015.0 | 619.96 |
| 70 | 352.87 | 114.01 | 13.72 | 29643.20 | 213.01 | 139.86 | 47.16 | 0.241 | 0.064 | 0.098 | 0.5989 | 3.30 | 3.10 | 25.73 | 8.31 | 0.66 | 116982.5 | 619.96 |
| 71 | 380.89 | 179.79 | 15.24 | 46802.70 | 199.50 | 181.39 | 58.67 | 0.170 | 0.076 | 0.084 | 0.7101 | 2.43 | 2.12 | 24.99 | 11.80 | 0.91 | 221258.0 | 346.49 |
| 72 | 516.66 | 265.56 | 12.80 | 96067.70 | 342.02 | 174.63 | 62.72 | 0.096 | 0.037 | 0.073 | 0.7265 | 2.18 | 1.95 | 40.36 | 20.74 | 0.51 | 372367.6 | 309.23 |
| 73 | 554.69 | 116.58 | 15.24 | 48811.80 | 289.56 | 265.13 | 59.08 | 0.261 | 0.053 | 0.057 | 0.5056 | 4.95 | 4.76 | 36.40 | 7.65 | 0.92 | 208933.3 | 273.50 |
| 74 | 596.81 | 189.01 | 51.82 | 78787.10 | 412.83 | 183.98 | 59.84 | 0.548 | 0.126 | 0.282 | 0.5635 | 3.55 | 3.16 | 11.52 | 3.65 | 0.45 | 1239144.3 | 273.50 |
| 75 | 655.22 | 191.19 | 15.24 | 87675.40 | 380.39 | 274.83 | 49.94 | 0.159 | 0.040 | 0.055 | 0.5427 | 3.85 | 3.43 | 42.99 | 12.54 | 0.72 | 404730.1 | 495.08 |
| 76 | 430.56 | 159.45 | 27.43 | 50733.20 | 241.08 | 189.48 | 60.37 | 0.344 | 0.114 | 0.145 | 0.6259 | 2.87 | 2.70 | 15.70 | 5.81 | 0.79 | 399249.8 | 877.91 |
| 77 | 658.14 | 347.88 | 33.53 | 180399.00 | 355.83 | 302.31 | 52.33 | 0.193 | 0.094 | 0.111 | 0.6928 | 1.89 | 1.89 | 19.63 | 10.38 | 0.85 | 1627389.3 | 707.48 |
| 78 | 540.42 | 135.84 | 15.24 | 55774.20 | 296.36 | 244.07 | 63.04 | 0.224 | 0.051 | 0.062 | 0.5496 | 4.11 | 3.98 | 35.46 | 8.91 | 0.82 | 237182.4 | 888.05 |
| 79 | 577.05 | 220.10 | 15.24 | 91855.70 | 347.20 | 229.85 | 58.66 | 0.138 | 0.044 | 0.066 | 0.6393 | 2.85 | 2.62 | 37.86 | 14.44 | 0.66 | 410361.1 | 739.54 |
| 80 | 643.52 | 285.50 | 21.34 | 154395.00 | 356.66 | 286.86 | 67.31 | 0.149 | 0.060 | 0.074 | 0.6642 | 2.11 | 2.25 | 30.16 | 13.38 | 0.80 | 831038.4 | 695.10 |
| 81 | 448.32 | 141.20 | 15.24 | 41859.10 | 251.70 | 196.62 | 63.34 | 0.216 | 0.061 | 0.078 | 0.5662 | 3.77 | 3.18 | 29.42 | 9.26 | 0.78 | 204524.0 | 203.11 |
| 82 | 494.02 | 166.38 | 21.34 | 59278.90 | 254.00 | 240.03 | 61.61 | 0.256 | 0.084 | 0.089 | 0.6213 | 3.23 | 2.97 | 23.15 | 7.80 | 0.94 | 371800.0 | 197.87 |
| 83 | 495.36 | 198.79 | 15.24 | 72546.50 | 251.10 | 244.26 | 69.96 | 0.153 | 0.061 | 0.062 | 0.6850 | 2.66 | 2.49 | 32.50 | 13.04 | 0.97 | 318146.8 | 197.87 |
| 84 | 531.54 | 178.21 | 12.80 | 68843.00 | 363.71 | 167.83 | 72.54 | 0.144 | 0.035 | 0.076 | 0.6181 | 3.22 | 2.98 | 41.52 | 13.92 | 0.46 | 257082.0 | 890.47 |
| 85 | 622.94 | 283.39 | 13.41 | 117782.00 | 366.73 | 256.21 | 49.58 | 0.095 | 0.037 | 0.052 | 0.6594 | 2.59 | 2.20 | 46.45 | 21.13 | 0.70 | 501928.5 | 1727.83 |
| 86 | 705.96 | 130.65 | 15.24 | 75154.80 | 516.09 | 189.87 | 64.21 | 0.233 | 0.030 | 0.080 | 0.4952 | 5.21 | 5.40 | 46.32 | 8.57 | 0.37 | 297989.5 | 1401.70 |
| 87 | 557.59 | 150.55 | 25.60 | 61993.60 | 322.86 | 234.73 | 60.61 | 0.340 | 0.079 | 0.109 | 0.5622 | 3.94 | 3.70 | 21.78 | 5.88 | 0.73 | 455650.1 | 598.38 |
| 88 | 658.73 | 203.19 | 15.24 | 98482.50 | 335.52 | 323.20 | 60.92 | 0.150 | 0.045 | 0.047 | 0.5582 | 3.46 | 3.24 | 43.22 | 13.33 | 0.96 | 432456.9 | 462.63 |
| 89 | 655.24 | 193.40 | 13.72 | 98855.80 | 348.76 | 306.48 | 84.08 | 0.142 | 0.039 | 0.045 | 0.5942 | 3.41 | 3.39 | 47.77 | 14.10 | 0.88 | 368481.2 | 220.23 |
| 90 | 477.59 | 173.78 | 21.34 | 66229.40 | 287.50 | 190.09 | 48.79 | 0.246 | 0.074 | 0.112 | 0.6353 | 2.70 | 2.75 | 22.38 | 8.14 | 0.66 | 375419.3 | 220.23 |
| 91 | 721.36 | 177.10 | 21.34 | 95190.30 | 377.15 | 344.22 | 59.74 | 0.241 | 0.057 | 0.062 | 0.5140 | 4.29 | 4.07 | 33.81 | 8.30 | 0.91 | 577876.9 | 525.24 |
| 92 | 544.92 | 215.42 | 15.24 | 80259.90 | 326.12 | 218.80 | 50.41 | 0.141 | 0.047 | 0.070 | 0.6395 | 2.91 | 2.53 | 35.76 | 14.14 | 0.67 | 379266.2 | 530.85 |
| 93 | 542.61 | 152.00 | 21.34 | 65633.80 | 375.77 | 166.84 | 61.06 | 0.281 | 0.057 | 0.128 | 0.5570 | 3.52 | 3.57 | 25.43 | 7.12 | 0.44 | 373062.4 | 355.89 |
| 94 | 785.14 | 262.06 | 33.53 | 159998.00 | 445.65 | 339.49 | 65.99 | 0.256 | 0.075 | 0.099 | 0.6275 | 3.03 | 3.00 | 23.42 | 7.82 | 0.76 | 1462494.8 | 355.89 |
| 95 | 552.67 | 241.63 | 21.34 | 93960.90 | 295.22 | 257.44 | 58.83 | 0.177 | 0.072 | 0.083 | 0.6565 | 2.55 | 2.29 | 25.90 | 11.32 | 0.87 | 604031.4 | 800.89 |
| 96 | 668.31 | 173.63 | 15.24 | 87282.70 | 466.24 | 202.07 | 48.37 | 0.176 | 0.033 | 0.075 | 0.5539 | 4.02 | 3.85 | 43.85 | 11.39 | 0.43 | 374914.0 | 1628.96 |
| 97 | 695.50 | 160.06 | 33.53 | 89435.70 | 359.51 | 335.99 | 59.55 | 0.419 | 0.093 | 0.100 | 0.5398 | 4.25 | 4.35 | 20.74 | 4.77 | 0.93 | 791287.5 | 1016.65 |
| 98 | 334.32 | 136.51 | 21.34 | 34974.00 | 225.48 | 108.84 | 62.47 | 0.313 | 0.095 | 0.196 | 0.6168 | 2.51 | 2.45 | 15.67 | 6.40 | 0.48 | 206434.9 | 436.96 |
| 99 | 474.13 | 196.25 | 15.24 | 77474.10 | 291.58 | 182.55 | 64.81 | 0.155 | 0.052 | 0.083 | 0.6322 | 2.28 | 2.42 | 31.11 | 12.88 | 0.63 | 300629.1 | 269.86 |
| 100 | 904.23 | 254.56 | 31.70 | 173494.00 | 598.24 | 306.00 | 61.38 | 0.249 | 0.053 | 0.104 | 0.5458 | 3.70 | 3.55 | 28.53 | 8.03 | 0.51 | 1546880.4 | 269.86 |
| 101 | 668.54 | 171.52 | 15.24 | 84478.60 | 393.78 | 274.76 | 60.22 | 0.178 | 0.039 | 0.055 | 0.5342 | 4.16 | 3.90 | 43.87 | 11.25 | 0.70 | 370484.4 | 403.23 |
| 102 | 382.16 | 109.96 | 21.34 | 38087.20 | 198.90 | 183.25 | 54.84 | 0.388 | 0.107 | 0.116 | 0.6228 | 3.01 | 3.48 | 17.91 | 5.15 | 0.92 | 190080.6 | 846.36 |
| 103 | 644.55 | 239.38 | 27.43 | 104699.00 | 381.72 | 262.82 | 55.58 | 0.229 | 0.072 | 0.104 | 0.6131 | 3.12 | 2.69 | 23.50 | 8.73 | 0.69 | 897284.4 | 307.13 |
| 104 | 262.32 | 70.80 | 15.24 | 14453.80 | 137.97 | 124.35 | 45.53 | 0.431 | 0.110 | 0.123 | 0.5454 | 3.74 | 3.71 | 17.21 | 4.65 | 0.90 | 60003.2 | 307.13 |
| 105 | 374.65 | 93.39 | 15.24 | 25003.20 | 191.64 | 183.01 | 56.55 | 0.326 | 0.080 | 0.083 | 0.5210 | 4.41 | 4.01 | 24.58 | 6.13 | 0.95 | 113049.1 | 341.97 |
| 106 | 882.37 | 263.42 | 33.53 | 180034.00 | 492.63 | 389.75 | 51.06 | 0.255 | 0.068 | 0.086 | 0.5953 | 3.40 | 3.35 | 26.32 | 7.86 | 0.79 | 1652173.9 | 436.98 |
| 107 | 579.16 | 148.99 | 15.24 | 75344.50 | 308.07 | 271.09 | 49.14 | 0.205 | 0.049 | 0.056 | 0.5635 | 3.50 | 3.89 | 38.00 | 9.78 | 0.88 | 278796.5 | 230.25 |
| 108 | 606.38 | 134.08 | 15.24 | 63079.90 | 340.48 | 265.90 | 50.51 | 0.227 | 0.045 | 0.057 | 0.5293 | 4.58 | 4.52 | 39.79 | 8.80 | 0.78 | 262678.3 | 230.25 |
| 109 | 655.52 | 191.27 | 15.24 | 103846.00 | 368.61 | 286.91 | 57.50 | 0.159 | 0.041 | 0.053 | 0.5991 | 3.25 | 3.43 | 43.01 | 12.55 | 0.78 | 405086.1 | 355.29 |
| 110 | 905.30 | 323.52 | 21.34 | 204770.00 | 489.01 | 416.28 | 53.18 | 0.132 | 0.044 | 0.051 | 0.6238 | 3.14 | 2.80 | 42.43 | 15.16 | 0.85 | 1324786.3 | 355.29 |
| 111 | 930.08 | 195.80 | 21.34 | 154455.00 | 511.13 | 418.95 | 44.04 | 0.218 | 0.042 | 0.051 | 0.5166 | 4.40 | 4.75 | 43.59 | 9.18 | 0.82 | 823725.7 | 507.64 |
| 112 | 929.44 | 87.24 | 21.34 | 60523.10 | 695.50 | 233.95 | 62.87 | 0.489 | 0.031 | 0.091 | 0.3402 | 11.21 | 10.65 | 43.56 | 4.09 | 0.34 | 366748.6 | 507.64 |

# Tobacco Plains/Stillwater Valley Data – Drumlin Delineation Definition #2

| Drum_ID | DL (m) | DW (m) | DH (m) | $DA_b$ ($m^2$) | $DL_T$ | $DL_{st}$ | DO | $DS_I$ | $DS_{II}$ | $DS_{st}$ | DCR | K | L/W | L/H | W/H | L/S | DV ($m^3$) | DNN (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 113 | 423.46 | 167.21 | 21.34 | 57170.20 | 229.68 | 193.78 | 51.67 | 0.255 | 0.093 | 0.110 | 0.6068 | 2.46 | 2.53 | 19.85 | 7.84 | 0.84 | 320282.11 | 1341.42 |
| 114 | 886.70 | 167.68 | 15.24 | 112821.00 | 649.26 | 237.45 | 46.82 | 0.182 | 0.023 | 0.064 | 0.4833 | 5.47 | 5.29 | 58.18 | 11.00 | 0.37 | 480373.81 | 1215.51 |
| 115 | 345.17 | 100.59 | 15.24 | 26939.60 | 220.76 | 124.41 | 68.28 | 0.303 | 0.069 | 0.122 | 0.5898 | 3.47 | 3.43 | 22.65 | 6.60 | 0.56 | 112173.83 | 501.48 |
| 116 | 617.59 | 151.89 | 21.34 | 72825.50 | 320.44 | 297.15 | 47.38 | 0.281 | 0.067 | 0.072 | 0.5432 | 4.11 | 4.07 | 28.95 | 7.12 | 0.93 | 424319.49 | 501.48 |
| 117 | 472.51 | 181.40 | 15.24 | 64522.30 | 262.43 | 210.09 | 53.73 | 0.168 | 0.058 | 0.073 | 0.6223 | 2.72 | 2.60 | 31.00 | 11.90 | 0.80 | 276936.43 | 409.26 |
| 118 | 642.98 | 120.49 | 15.24 | 63891.70 | 364.36 | 278.62 | 60.30 | 0.253 | 0.042 | 0.055 | 0.4852 | 5.08 | 5.34 | 42.19 | 7.91 | 0.76 | 250316.07 | 409.26 |
| 119 | 552.15 | 150.83 | 15.24 | 70612.00 | 302.92 | 249.23 | 55.08 | 0.202 | 0.050 | 0.061 | 0.5760 | 3.39 | 3.66 | 36.23 | 9.90 | 0.82 | 269064.83 | 414.87 |
| 120 | 882.24 | 342.16 | 13.41 | 224106.00 | 525.49 | 356.75 | 57.32 | 0.078 | 0.026 | 0.038 | 0.6117 | 2.73 | 2.58 | 65.78 | 25.51 | 0.68 | 858272.47 | 1178.45 |
| 121 | 723.63 | 249.50 | 15.24 | 156184.00 | 373.99 | 349.64 | 58.54 | 0.122 | 0.041 | 0.044 | 0.6012 | 2.63 | 2.90 | 47.48 | 16.37 | 0.93 | 583340.06 | 409.67 |
| 122 | 415.08 | 202.72 | 15.24 | 63370.20 | 252.00 | 163.09 | 55.48 | 0.150 | 0.060 | 0.093 | 0.6836 | 2.14 | 2.05 | 27.24 | 13.30 | 0.65 | 271865.96 | 409.67 |
| 123 | 449.20 | 171.04 | 15.24 | 55236.90 | 256.37 | 192.84 | 53.63 | 0.178 | 0.059 | 0.079 | 0.6241 | 2.87 | 2.63 | 29.47 | 11.22 | 0.75 | 248233.40 | 505.80 |
| 124 | 451.56 | 135.26 | 15.24 | 42128.60 | 280.66 | 170.91 | 78.42 | 0.225 | 0.054 | 0.089 | 0.5662 | 3.80 | 3.34 | 29.63 | 8.87 | 0.61 | 197331.88 | 505.80 |
| 125 | 1165.28 | 194.73 | 21.34 | 156613.00 | 826.19 | 339.10 | 67.62 | 0.219 | 0.026 | 0.063 | 0.4292 | 6.81 | 5.98 | 54.61 | 9.13 | 0.41 | 1026419.32 | 1159.98 |
| 126 | 748.85 | 352.59 | 21.34 | 202354.00 | 419.35 | 329.51 | 72.67 | 0.121 | 0.051 | 0.065 | 0.6632 | 2.18 | 2.12 | 35.10 | 16.53 | 0.79 | 1194320.69 | 996.96 |
| 127 | 524.38 | 165.49 | 15.24 | 61060.50 | 294.18 | 230.19 | 68.72 | 0.184 | 0.052 | 0.066 | 0.5538 | 3.54 | 3.17 | 34.41 | 10.86 | 0.78 | 280382.41 | 247.87 |
| 128 | 510.97 | 229.49 | 27.43 | 97155.30 | 258.00 | 252.97 | 65.93 | 0.239 | 0.106 | 0.108 | 0.6410 | 2.11 | 2.23 | 18.63 | 8.37 | 0.98 | 681938.55 | 247.87 |
| 129 | 1081.71 | 245.67 | 39.62 | 212216.00 | 665.97 | 415.74 | 60.03 | 0.323 | 0.059 | 0.095 | 0.5236 | 4.33 | 4.40 | 27.30 | 6.20 | 0.62 | 2232369.92 | 479.01 |
| 130 | 423.46 | 154.17 | 15.24 | 50791.50 | 232.57 | 190.89 | 65.81 | 0.198 | 0.066 | 0.080 | 0.6316 | 2.77 | 2.75 | 27.79 | 10.12 | 0.82 | 210934.69 | 506.73 |
| 131 | 690.40 | 202.41 | 30.48 | 110522.00 | 368.25 | 322.14 | 52.59 | 0.301 | 0.083 | 0.095 | 0.5734 | 3.39 | 3.41 | 22.65 | 6.64 | 0.87 | 902983.24 | 506.73 |
| 132 | 943.78 | 269.48 | 21.34 | 166539.00 | 716.47 | 227.31 | 68.95 | 0.158 | 0.030 | 0.094 | 0.5357 | 4.20 | 3.50 | 44.23 | 12.63 | 0.32 | 1150401.70 | 866.46 |
| 133 | 752.90 | 248.32 | 30.48 | 141026.00 | 465.94 | 286.96 | 46.92 | 0.245 | 0.065 | 0.106 | 0.6366 | 3.16 | 3.03 | 24.70 | 8.15 | 0.62 | 1208089.578 | 1159.98 |
| 134 | 1005.31 | 144.00 | 18.29 | 107606.00 | 763.48 | 241.83 | 66.32 | 0.254 | 0.024 | 0.076 | 0.4221 | 7.38 | 6.98 | 54.97 | 7.87 | 0.32 | 561255.0611 | 679.07 |
| 135 | 909.29 | 240.69 | 18.29 | 131807.00 | 491.95 | 417.34 | 60.78 | 0.152 | 0.037 | 0.044 | 0.5082 | 4.93 | 3.78 | 49.72 | 13.16 | 0.85 | 848537.2145 | 679.07 |
| 136 | 1433.46 | 215.88 | 18.29 | 210199.00 | 908.40 | 525.06 | 58.29 | 0.169 | 0.020 | 0.035 | 0.4171 | 7.68 | 6.64 | 78.38 | 11.80 | 0.58 | 1199794.38 | 591.95 |
| 137 | 856.93 | 212.17 | 18.29 | 145594.00 | 466.45 | 390.47 | 53.30 | 0.172 | 0.039 | 0.047 | 0.5485 | 3.96 | 4.04 | 46.86 | 11.60 | 0.84 | 704897.4379 | 1104.72 |
| 138 | 370.09 | 169.69 | 15.85 | 44634.80 | 213.94 | 156.14 | 65.47 | 0.187 | 0.074 | 0.102 | 0.6893 | 2.41 | 2.18 | 23.35 | 10.71 | 0.73 | 211019.9228 | 1158.97 |
| 139 | 509.28 | 266.82 | 30.48 | 96856.40 | 276.27 | 233.01 | 42.54 | 0.228 | 0.110 | 0.131 | 0.7085 | 2.10 | 1.91 | 16.71 | 8.75 | 0.84 | 878070.1212 | 1239.99 |
| 140 | 567.43 | 167.45 | 13.72 | 74094.50 | 347.73 | 219.70 | 69.12 | 0.164 | 0.039 | 0.062 | 0.5981 | 3.41 | 3.39 | 41.37 | 12.21 | 0.63 | 276280.5552 | 1116.74 |
| 141 | 630.93 | 246.42 | 19.81 | 117345.00 | 352.72 | 278.21 | 75.82 | 0.161 | 0.056 | 0.071 | 0.6388 | 2.66 | 2.56 | 31.85 | 12.44 | 0.79 | 653022.9569 | 696.81 |
| 142 | 566.42 | 148.74 | 19.81 | 66812.80 | 300.45 | 265.97 | 68.51 | 0.266 | 0.066 | 0.074 | 0.5647 | 3.77 | 3.81 | 28.59 | 7.51 | 0.89 | 353864.6836 | 696.81 |
| 143 | 794.03 | 108.63 | 18.29 | 60212.40 | 499.52 | 294.51 | 67.05 | 0.337 | 0.037 | 0.062 | 0.3802 | 8.22 | 7.31 | 43.42 | 5.94 | 0.59 | 334426.7151 | 749.09 |
| 144 | 556.33 | 120.91 | 14.33 | 48196.00 | 287.97 | 268.36 | 68.16 | 0.237 | 0.050 | 0.053 | 0.5310 | 5.04 | 4.60 | 38.83 | 8.44 | 0.93 | 204288.0874 | 749.09 |
| 145 | 726.66 | 258.77 | 20.12 | 140211.00 | 402.93 | 323.73 | 70.83 | 0.155 | 0.050 | 0.062 | 0.5807 | 2.96 | 2.81 | 36.12 | 12.86 | 0.80 | 801946.392 | 806.10 |
| 146 | 943.63 | 295.43 | 42.67 | 191794.00 | 567.12 | 376.50 | 76.00 | 0.289 | 0.075 | 0.113 | 0.6016 | 3.65 | 3.19 | 22.11 | 6.92 | 0.66 | 2521975.835 | 806.10 |
| 147 | 1336.44 | 280.07 | 18.29 | 285688.00 | 688.56 | 647.88 | 65.02 | 0.131 | 0.027 | 0.028 | 0.5056 | 4.91 | 4.77 | 73.08 | 15.31 | 0.94 | 1451159.426 | 591.95 |
| 1b | 485.22 | 124.17 | 9.14 | 40923.29 | 282.55 | 202.67 | 81.79 | 0.147 | 0.032 | 0.045 | 0.5464 | 4.52 | 3.91 | 53.06 | 13.58 | 0.72 | 116796.11 | 921.32 |
| 2b | 385.05 | 113.21 | 9.14 | 31185.60 | 268.22 | 116.84 | 88.94 | 0.162 | 0.034 | 0.078 | 0.5989 | 3.73 | 3.40 | 42.11 | 12.38 | 0.44 | 84508.02 | 413.77 |
| 3b | 288.84 | 171.26 | 9.14 | 37940.29 | 153.11 | 135.73 | 76.18 | 0.107 | 0.060 | 0.067 | 0.7566 | 1.73 | 1.69 | 31.59 | 18.73 | 0.89 | 95891.57 | 1247.71 |
| 4b | 517.07 | 170.02 | 9.14 | 60258.68 | 259.33 | 257.74 | 79.61 | 0.108 | 0.035 | 0.035 | 0.6495 | 3.48 | 3.04 | 56.55 | 18.59 | 0.99 | 170425.73 | 375.50 |
| 5b | 229.98 | 96.28 | 9.14 | 18416.80 | 123.20 | 106.78 | 98.69 | 0.190 | 0.074 | 0.086 | 0.7024 | 2.26 | 2.39 | 25.15 | 10.53 | 0.87 | 42925.36 | 1448.38 |
| 6b | 440.46 | 157.65 | 9.14 | 62751.30 | 224.40 | 216.07 | 81.04 | 0.116 | 0.041 | 0.042 | 0.6401 | 2.43 | 2.79 | 48.17 | 17.24 | 0.96 | 134612.45 | 213.15 |
| 7b | 494.91 | 130.94 | 9.14 | 48361.74 | 266.42 | 228.49 | 83.67 | 0.140 | 0.034 | 0.040 | 0.5865 | 3.98 | 3.78 | 54.12 | 14.32 | 0.86 | 125625.90 | 213.15 |
| 8b | 400.03 | 213.13 | 9.14 | 62796.68 | 211.53 | 188.50 | 81.24 | 0.086 | 0.043 | 0.049 | 0.7521 | 2.00 | 1.88 | 43.75 | 23.31 | 0.89 | 165274.31 | 309.70 |
| 9b | 437.19 | 114.03 | 9.14 | 34343.11 | 225.26 | 211.93 | 67.49 | 0.160 | 0.041 | 0.043 | 0.5534 | 4.37 | 3.83 | 47.81 | 12.47 | 0.94 | 96641.28 | 871.29 |
| 10b | 354.18 | 108.92 | 9.14 | 26189.95 | 199.54 | 154.64 | 66.02 | 0.168 | 0.046 | 0.059 | 0.5756 | 3.76 | 3.25 | 38.73 | 11.91 | 0.77 | 74781.09 | 254.56 |
| 11b | 488.97 | 190.55 | 9.14 | 61490.54 | 290.36 | 198.60 | 59.41 | 0.096 | 0.031 | 0.046 | 0.6223 | 3.05 | 2.57 | 53.47 | 20.84 | 0.68 | 180621.14 | 450.81 |
| 12b | 418.19 | 136.43 | 9.14 | 40697.74 | 219.17 | 199.02 | 54.19 | 0.134 | 0.042 | 0.046 | 0.6076 | 3.37 | 3.07 | 45.73 | 14.92 | 0.91 | 110602.00 | 376.18 |
| 13b | 546.90 | 109.00 | 9.14 | 41299.71 | 319.61 | 227.29 | 57.86 | 0.168 | 0.029 | 0.040 | 0.4452 | 5.69 | 5.02 | 59.81 | 11.92 | 0.71 | 115563.66 | 377.89 |
| 14b | 540.25 | 170.65 | 9.14 | 73563.10 | 300.04 | 240.21 | 57.47 | 0.107 | 0.030 | 0.038 | 0.5908 | 3.12 | 3.17 | 59.08 | 18.66 | 0.80 | 178723.52 | 657.20 |
| 15b | 417.08 | 192.48 | 9.14 | 58999.03 | 245.72 | 171.36 | 53.25 | 0.095 | 0.037 | 0.053 | 0.6545 | 2.32 | 2.17 | 45.61 | 21.05 | 0.70 | 155621.63 | 735.81 |
| 16b | 738.31 | 130.94 | 9.14 | 75660.80 | 399.16 | 339.15 | 54.19 | 0.140 | 0.023 | 0.027 | 0.4669 | 5.66 | 5.64 | 80.74 | 14.32 | 0.85 | 187403.82 | 550.46 |
| 17b | 354.21 | 178.37 | 9.14 | 46639.26 | 184.33 | 169.88 | 50.51 | 0.103 | 0.050 | 0.054 | 0.7263 | 2.11 | 1.99 | 38.74 | 19.51 | 0.92 | 122476.45 | 244.69 |
| 18b | 332.34 | 92.54 | 9.14 | 22361.23 | 166.13 | 166.21 | 53.88 | 0.198 | 0.055 | 0.055 | 0.5667 | 3.88 | 3.59 | 36.34 | 10.12 | 1.00 | 59617.75 | 140.32 |
| 19b | 413.64 | 114.37 | 9.14 | 35441.37 | 208.81 | 204.84 | 56.44 | 0.160 | 0.044 | 0.045 | 0.5404 | 3.79 | 3.62 | 45.24 | 12.51 | 0.98 | 91708.86 | 389.98 |
| 20b | 374.69 | 79.59 | 9.14 | 23700.47 | 220.66 | 154.03 | 55.80 | 0.230 | 0.041 | 0.059 | 0.7789 | 4.65 | 4.71 | 40.98 | 8.70 | 0.70 | 57811.15 | 522.38 |
| 21b | 402.57 | 129.68 | 9.14 | 41530.29 | 200.41 | 202.16 | 63.30 | 0.141 | 0.046 | 0.045 | 0.5724 | 3.06 | 3.10 | 44.03 | 14.18 | 1.01 | 101203.11 | 524.07 |
| 22b | 417.45 | 130.10 | 9.14 | 45335.68 | 220.72 | 196.73 | 57.50 | 0.141 | 0.041 | 0.046 | 0.6027 | 3.02 | 3.21 | 45.65 | 14.23 | 0.89 | 105281.33 | 425.83 |
| 23b | 398.34 | 64.08 | 9.14 | 21374.88 | 218.35 | 179.98 | 61.98 | 0.285 | 0.042 | 0.051 | 0.4570 | 5.83 | 6.22 | 43.56 | 7.01 | 0.82 | 49478.84 | 226.05 |
| 24b | 581.82 | 78.56 | 7.01 | 32758.64 | 397.66 | 184.16 | 67.05 | 0.178 | 0.018 | 0.038 | 0.4194 | 8.12 | 7.41 | 83.00 | 11.21 | 0.46 | 67931.11 | 175.83 |

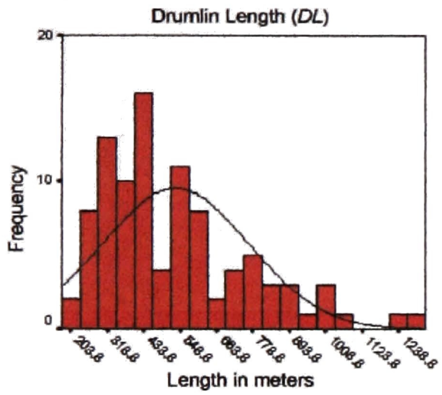
# APPENDIX F

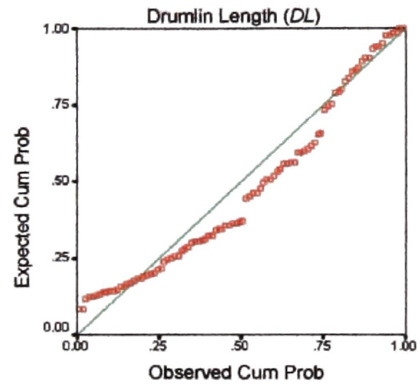
**“Normal” Histograms and Probability Plots**

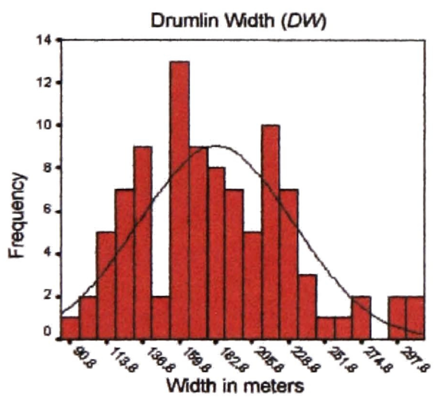
**Delineation Definition #1**

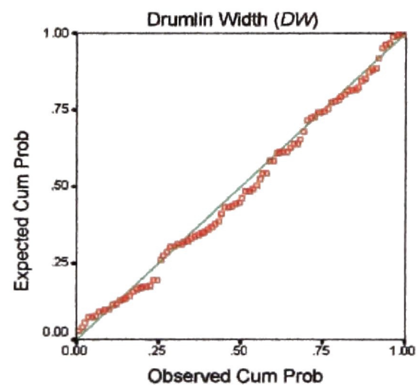
# “NORMAL” HISTOGRAMS & PROBABILITY PLOTS

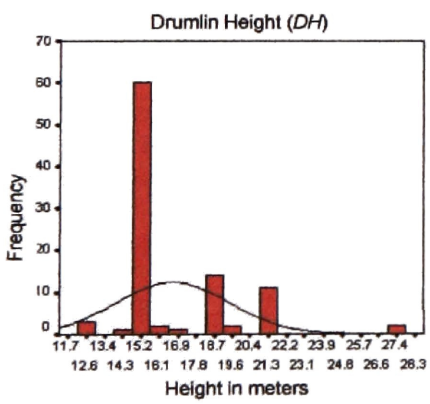
## Seeley/Swan Valley Metrics – Delineation Definition #1

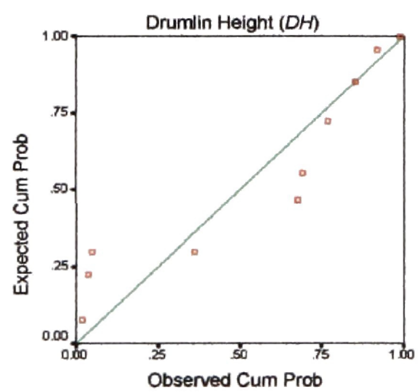


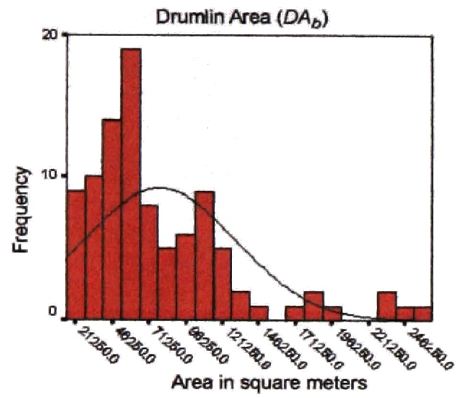



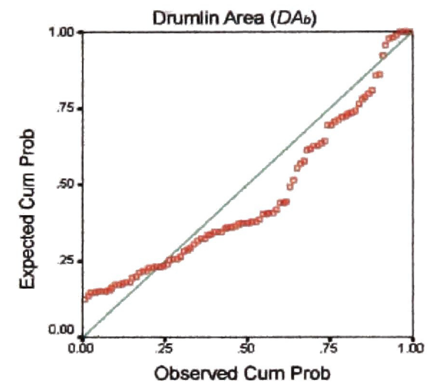



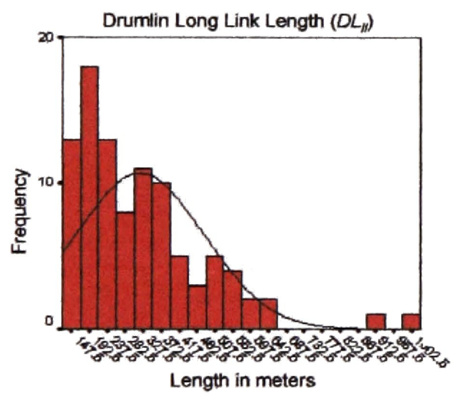



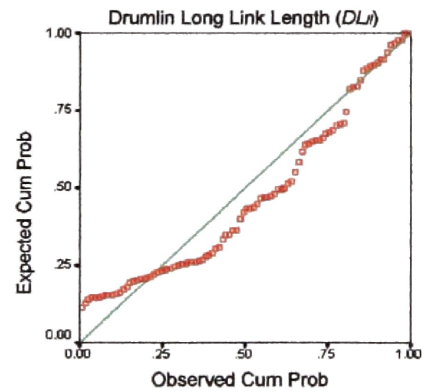
# "NORMAL" HISTOGRAMS & PROBABILITY PLOTS

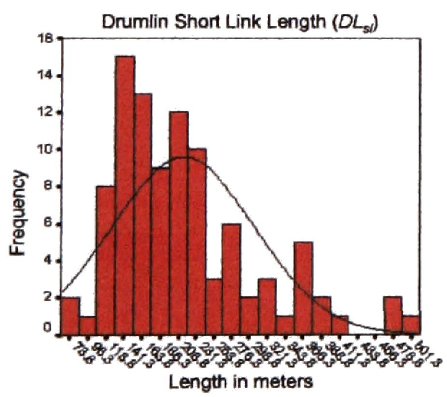
## Seeley/Swan Valley Metrics – Delineation Definition #1

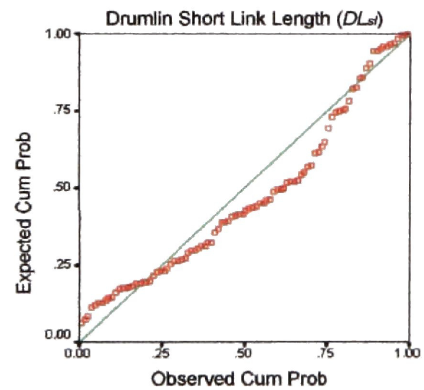


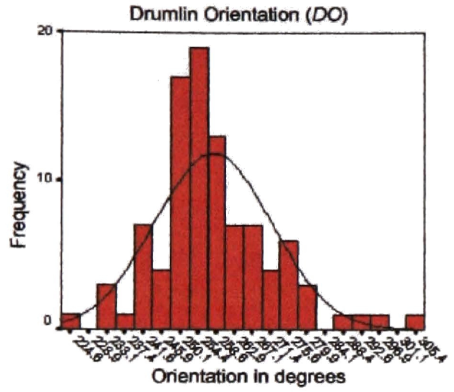



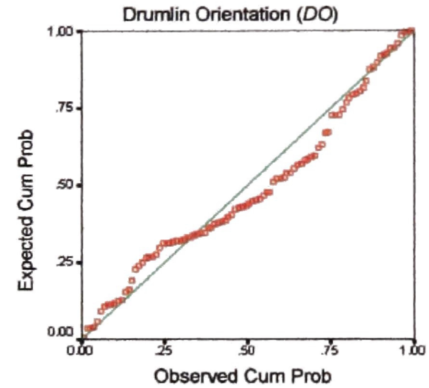



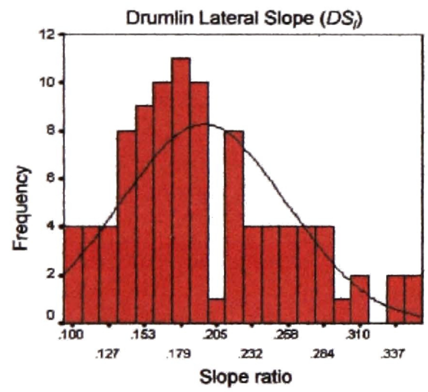



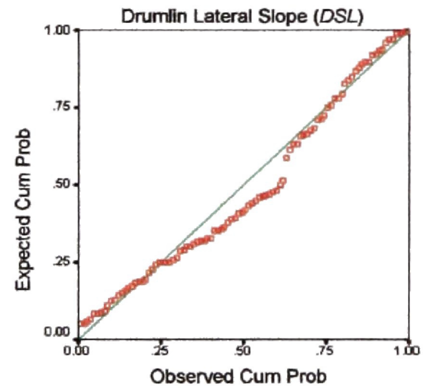
# “NORMAL” HISTOGRAMS & PROBABILITY PLOTS

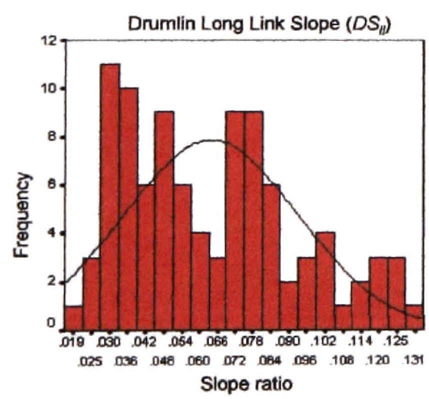
## Seeley/Swan Valley Metrics – Delineation Definition #1

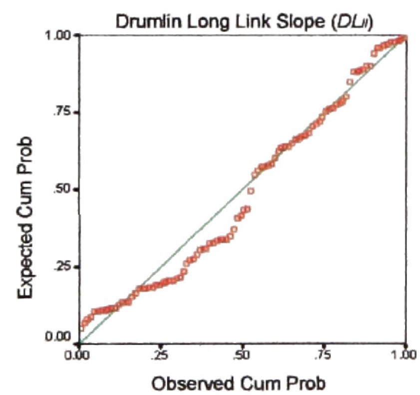


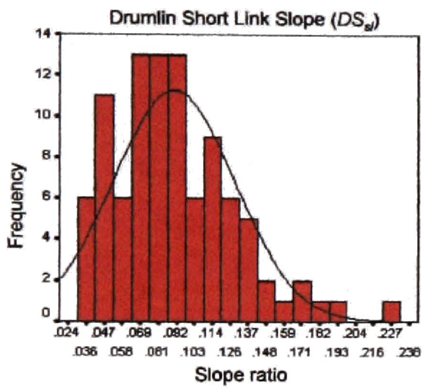



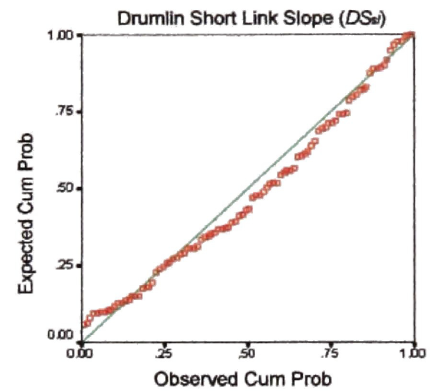



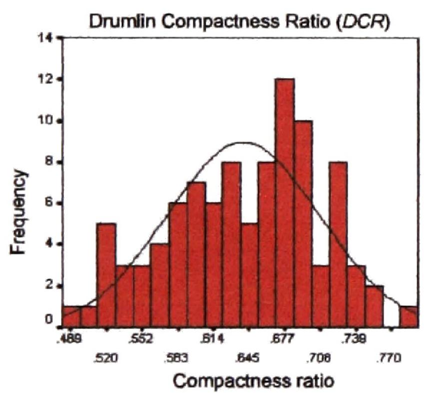



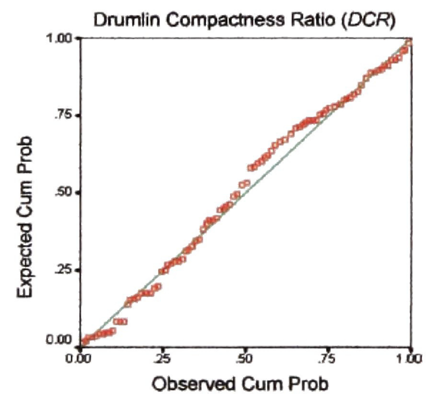
## "NORMAL" HISTOGRAMS & PROBABILITY PLOTS

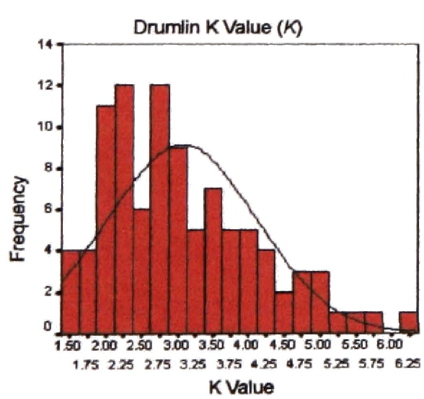
### Seeley/Swan Valley Metrics – Delineation Definition #1

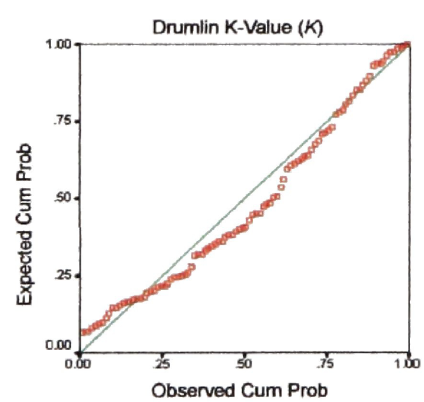


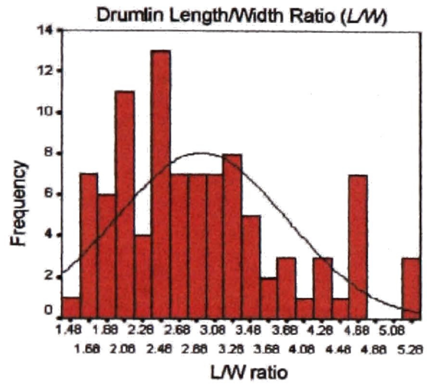



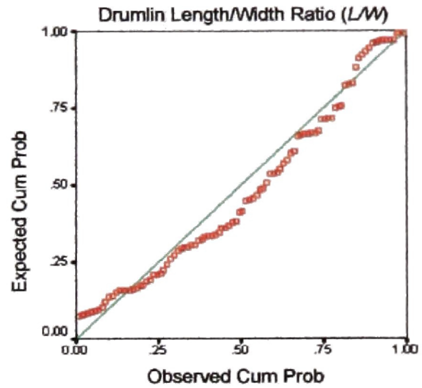



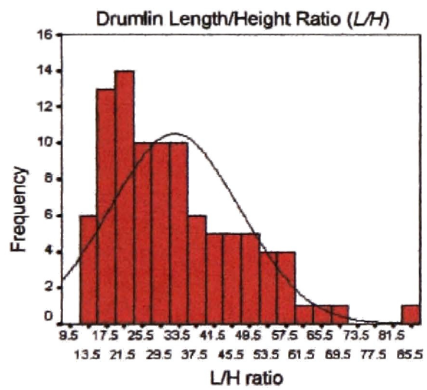



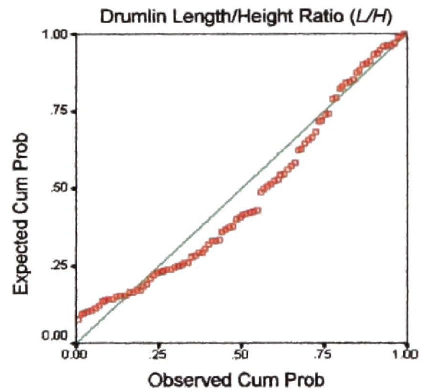
# "NORMAL" HISTOGRAMS & PROBABILITY PLOTS

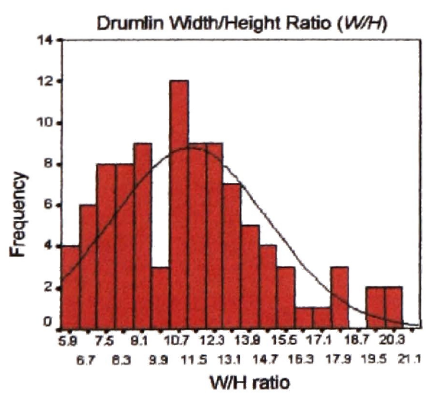
## Seeley/Swan Valley Metrics – Delineation Definition #1

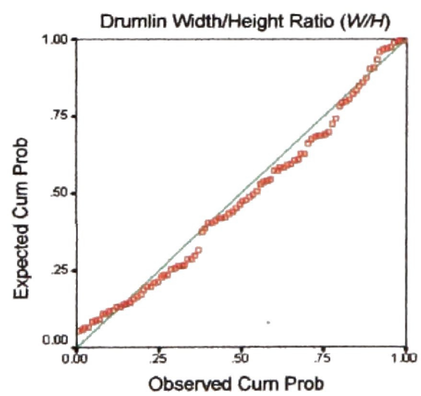


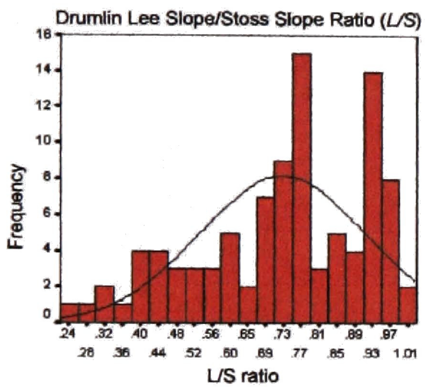



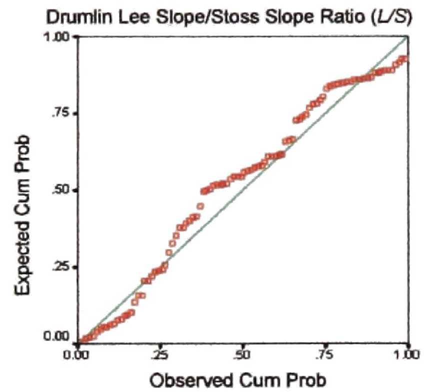



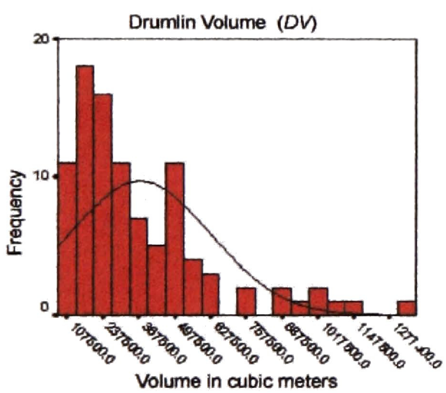



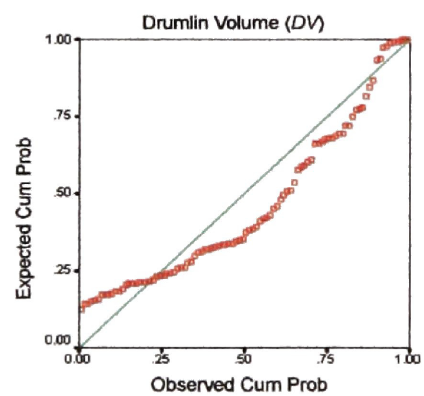
# “NORMAL” HISTOGRAMS & PROBABILITY PLOTS

## Seeley/Swan Valley Metrics – Delineation Definition #1



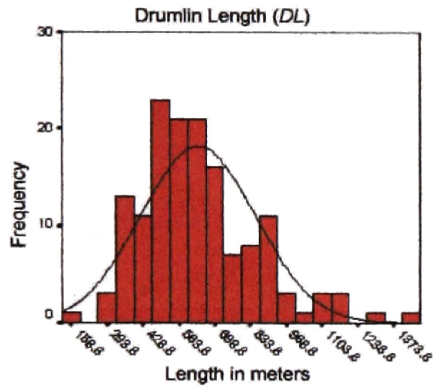



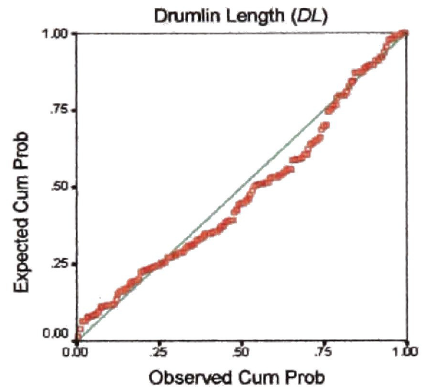



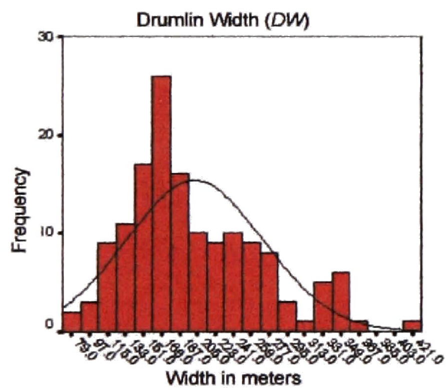



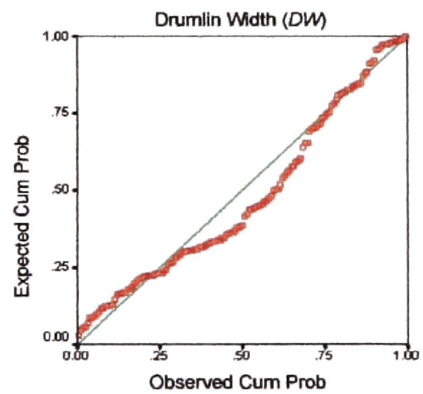
# “NORMAL” HISTOGRAMS & PROBABILITY PLOTS

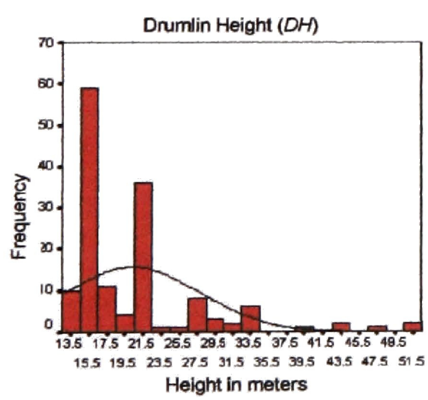
## Tobacco Plains/Stillwater Valley Metrics – Delineation Definition #1

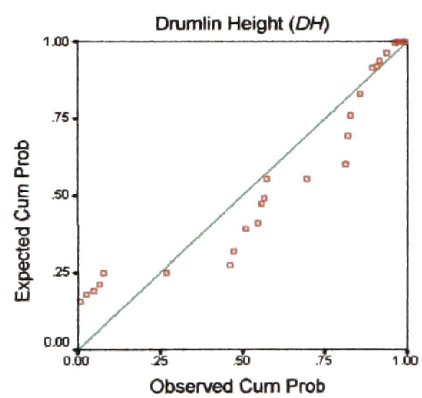


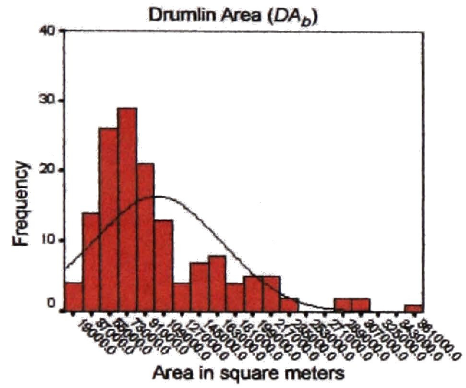



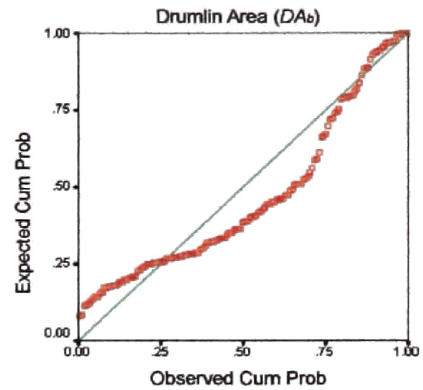



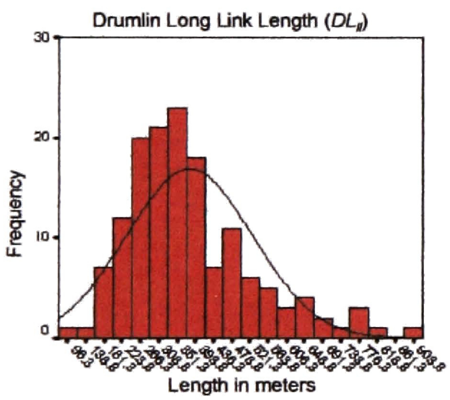



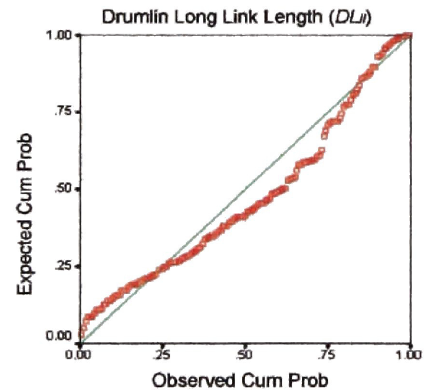
# "NORMAL" HISTOGRAMS & PROBABILITY PLOTS

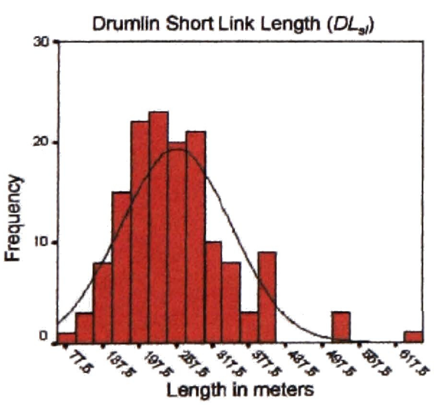
## Tobacco Plains/Stillwater Valley Metrics – Delineation Definition #1

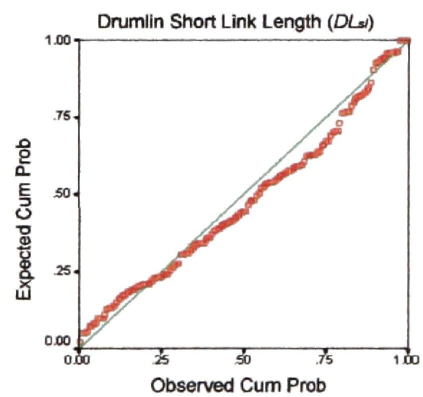


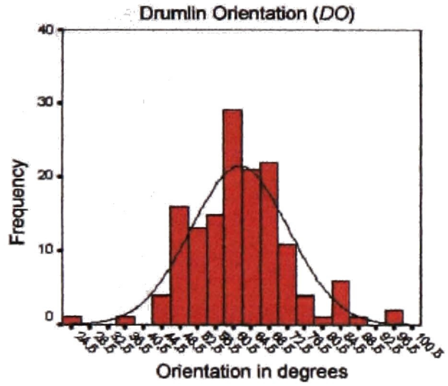



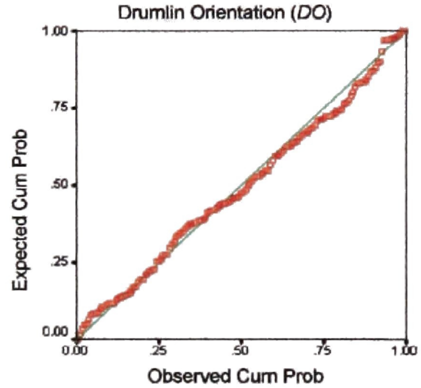



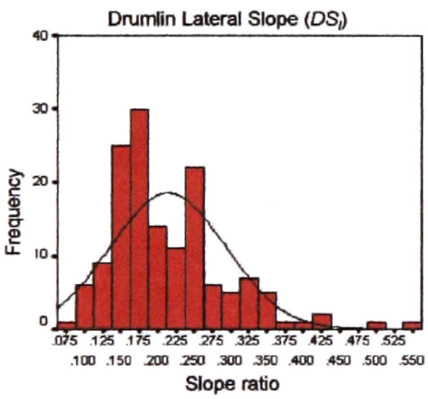



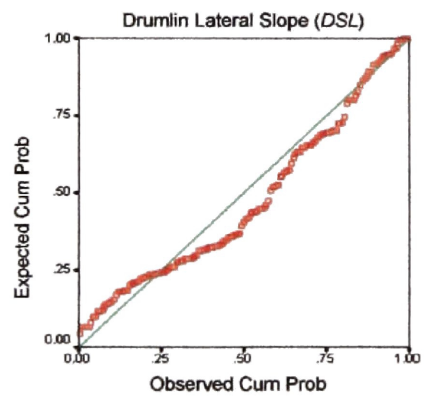
## "NORMAL" HISTOGRAMS & PROBABILITY PLOTS

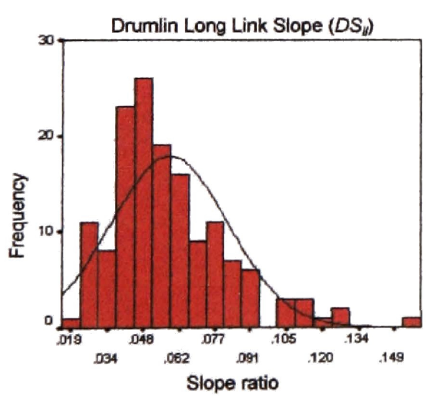
### Tobacco Plains/Stillwater Valley Metrics – Delineation Definition #1

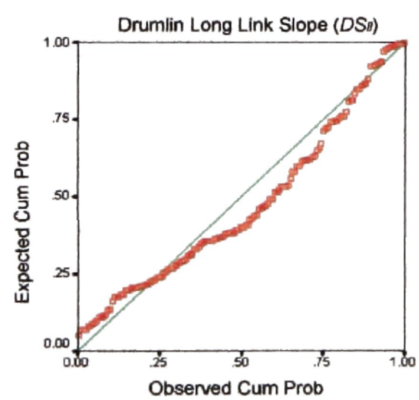


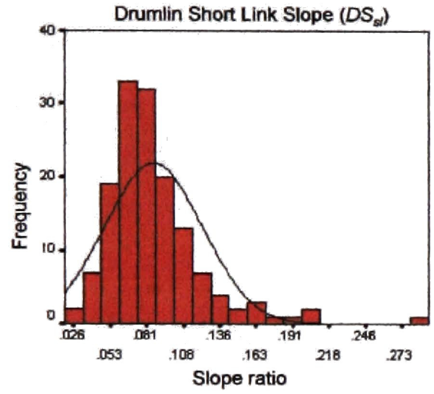



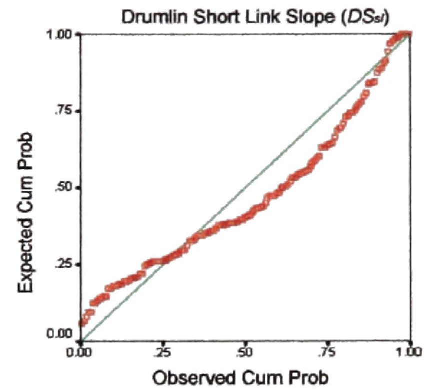



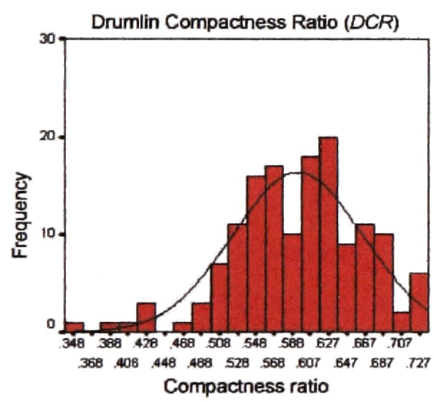



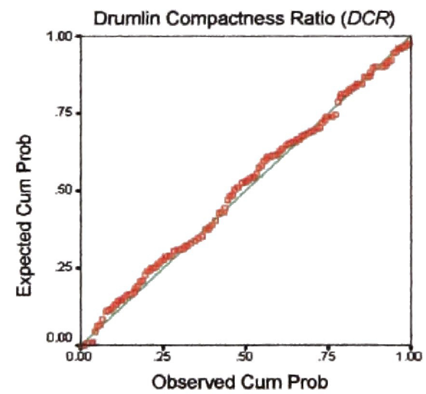
## "NORMAL" HISTOGRAMS & PROBABILITY PLOTS

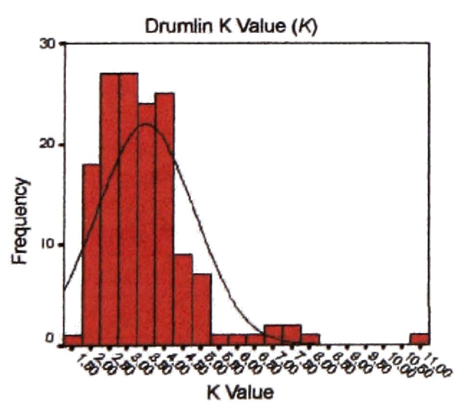
## Tobacco Plains/Stillwater Valley Metrics – Delineation Definition #1

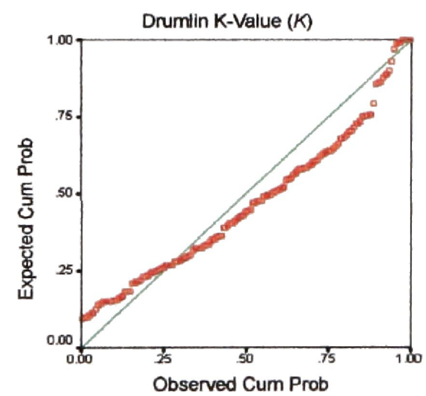


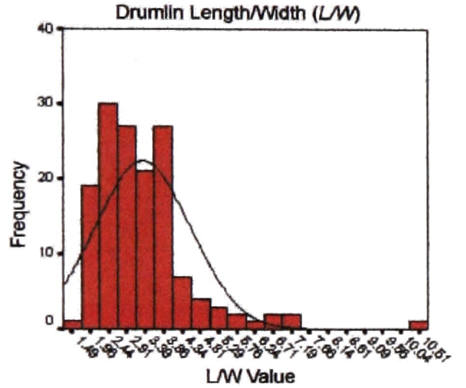



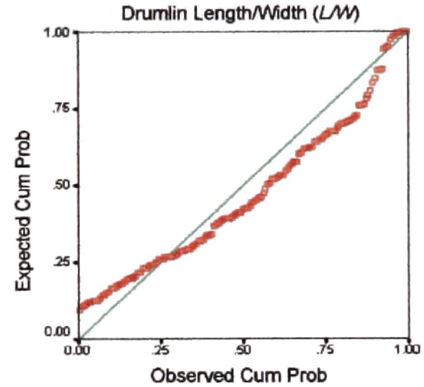



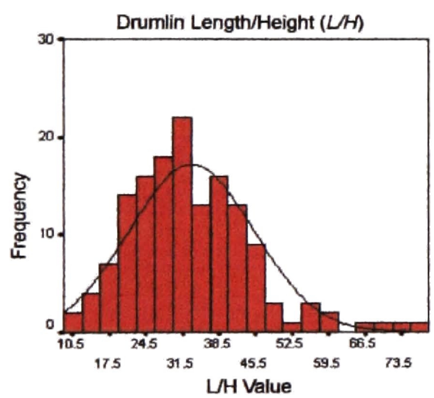



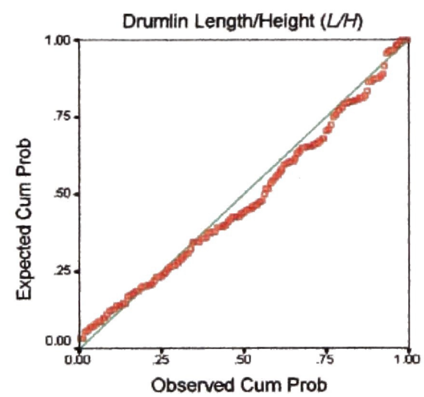
# "NORMAL" HISTOGRAMS & PROBABILITY PLOTS

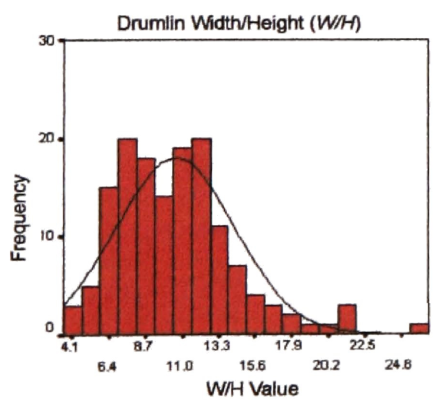
## Tobacco Plains/Stillwater Valley Metrics – Delineation Definition #1

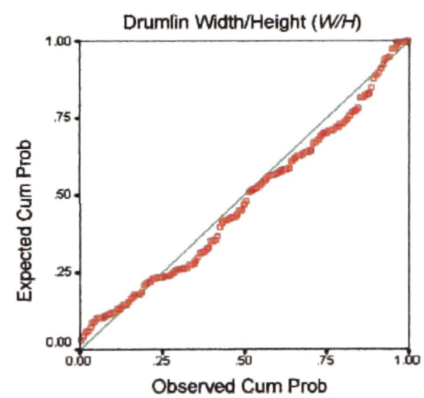


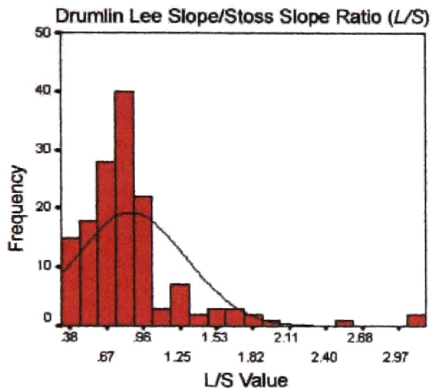



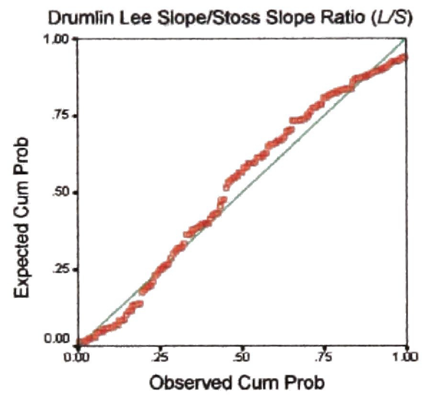



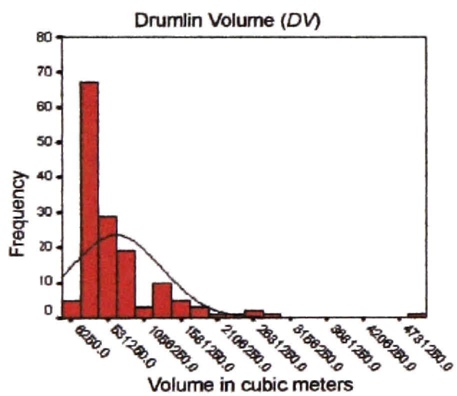



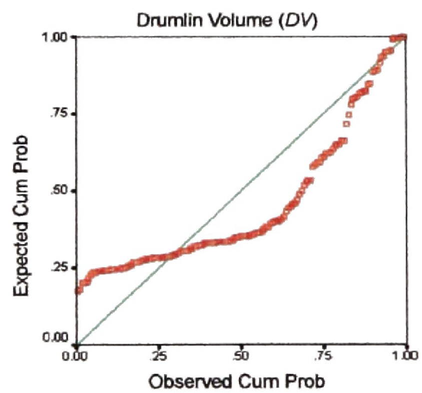
# "NORMAL" HISTOGRAMS & PROBABILITY PLOTS

## Tobacco Plains/Stillwater Valley Metrics – Delineation Definition #1



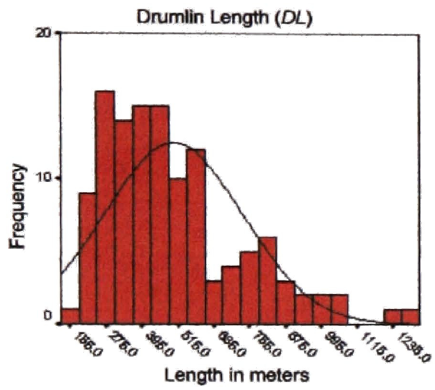
# APPENDIX G

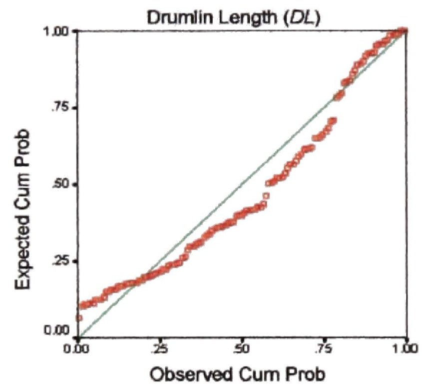
**“Normal” Histograms and Probability Plots**

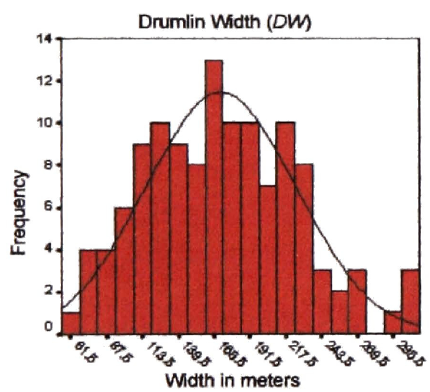
**Drumlin Delineation Definition #2**

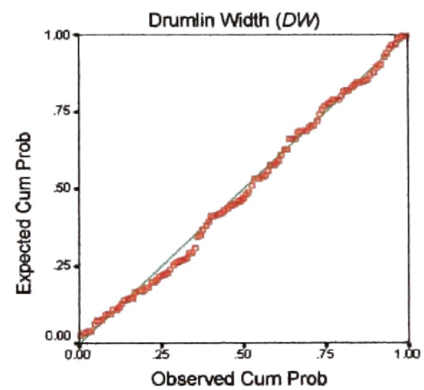
# "NORMAL" HISTOGRAMS & PROBABILITY PLOTS

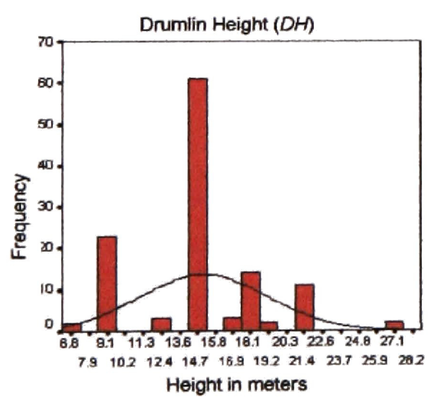
## Seeley/Swan Valley Metrics – Delineation Definition #2

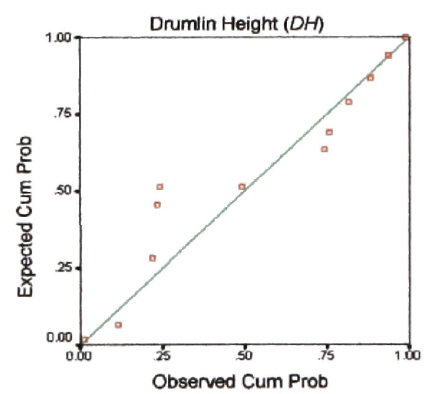


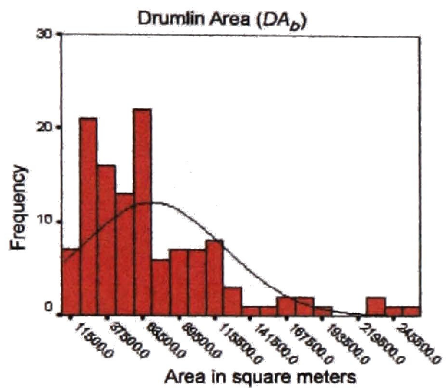



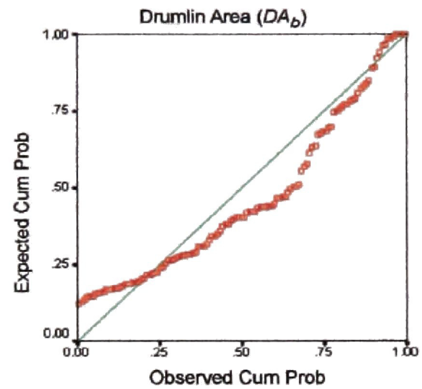



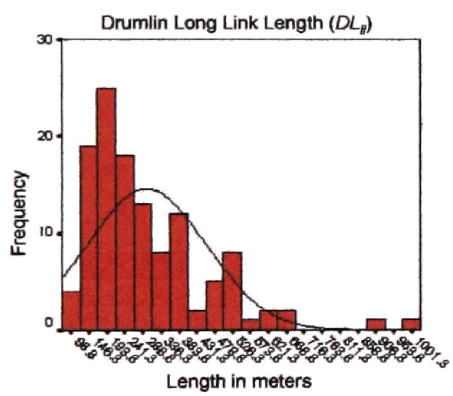



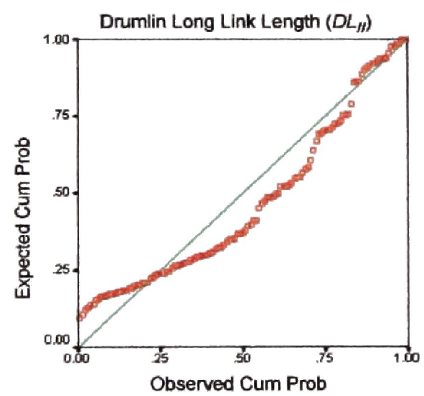
# “NORMAL” HISTOGRAMS & PROBABILITY PLOTS

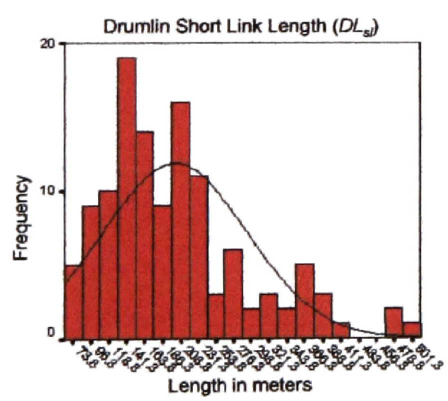
## Seeley/Swan Valley Metrics – Delineation Definition #2

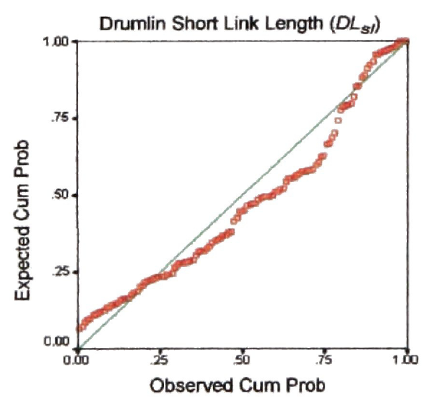


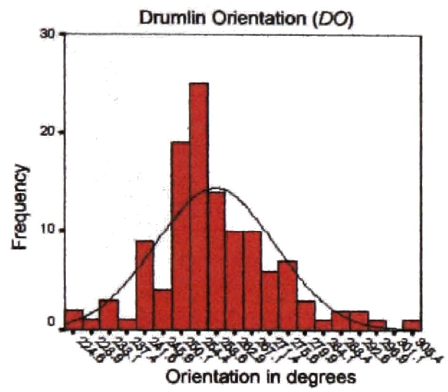



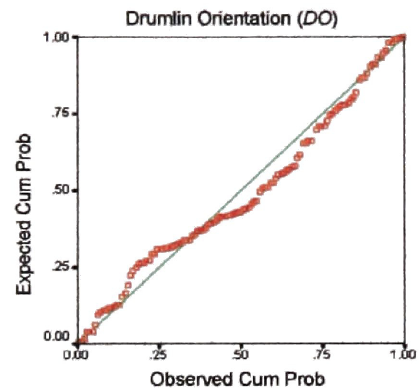



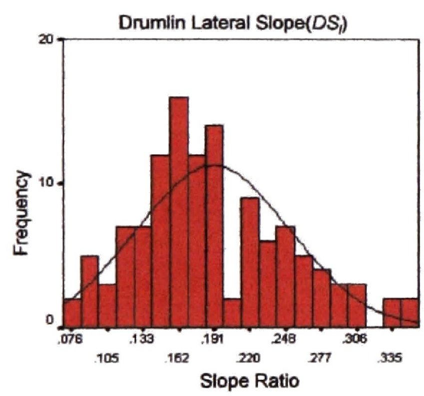



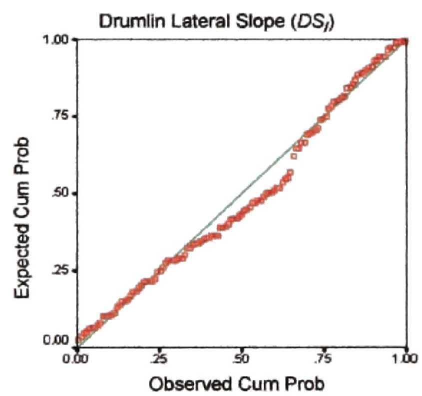
# “NORMAL” HISTOGRAMS & PROBABILITY PLOTS

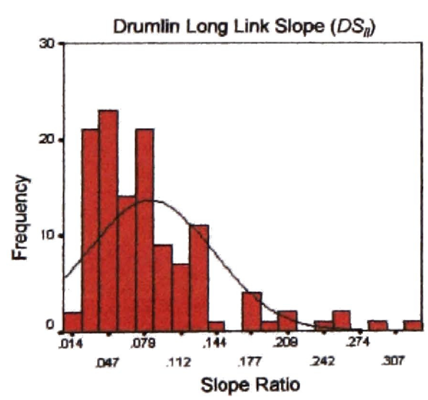
## Seeley/Swan Valley Metrics – Delineation Definition #2

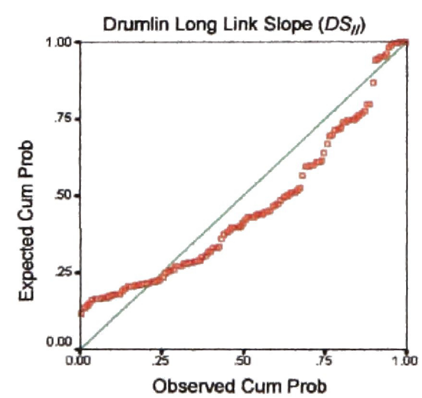


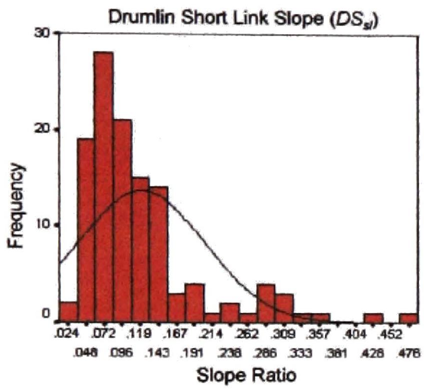



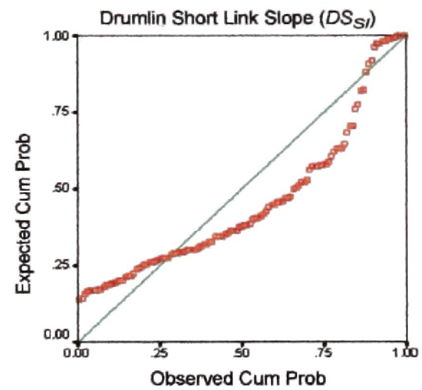



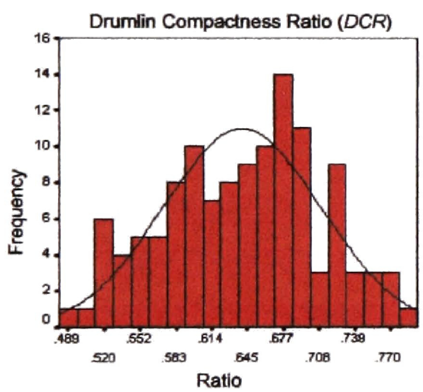



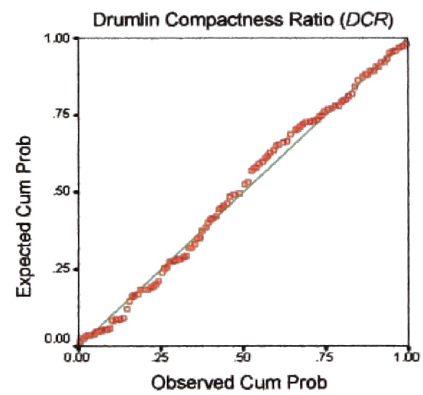
# "NORMAL" HISTOGRAMS & PROBABILITY PLOTS

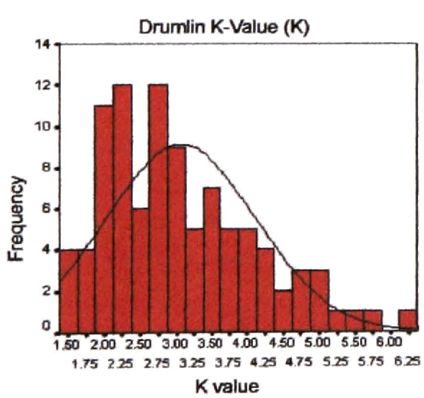
## Seeley/Swan Valley Metrics – Delineation Definition #2

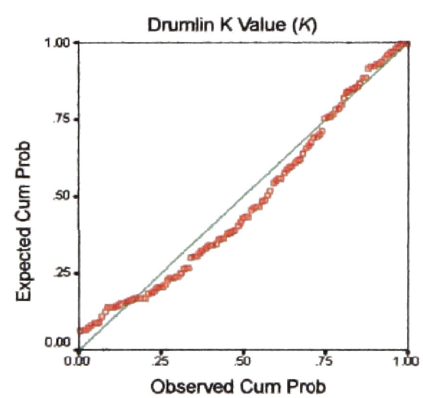


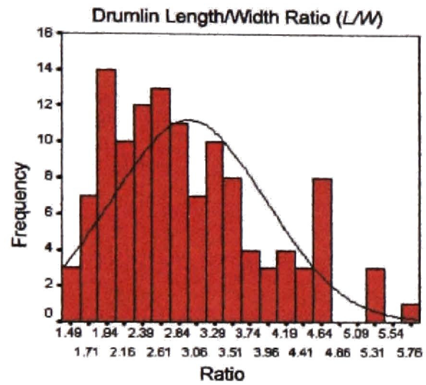



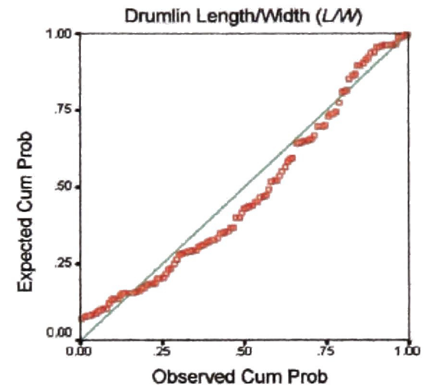



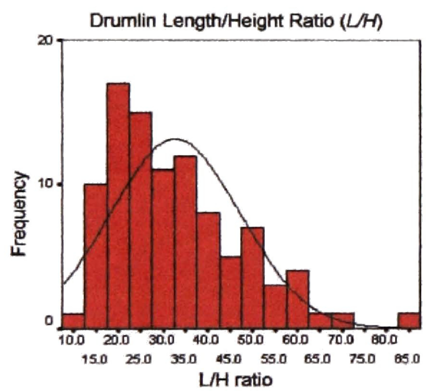



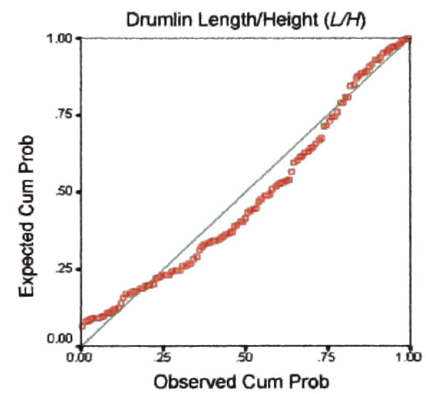
# “NORMAL” HISTOGRAMS & PROBABILITY PLOTS

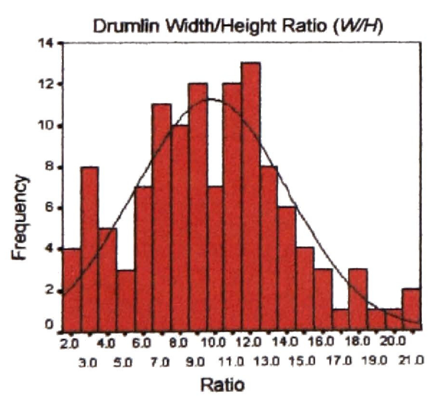
## Seeley/Swan Valley Metrics – Delineation Definition #2

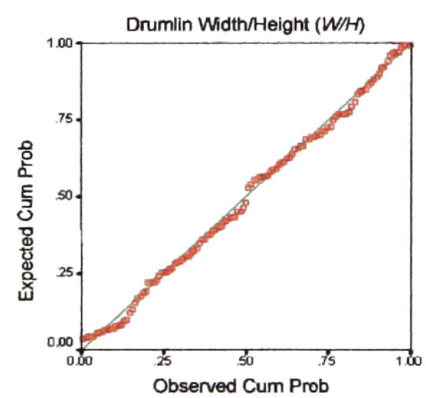


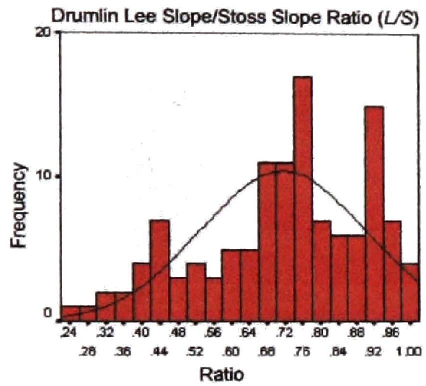



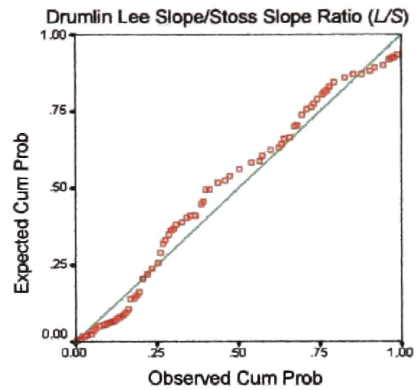



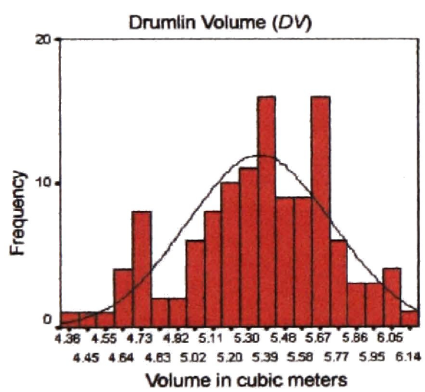



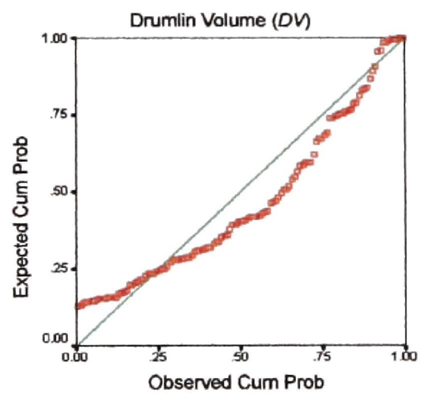
# "NORMAL" HISTOGRAMS & PROBABILITY PLOTS

## Seeley/Swan Valley Metrics – Delineation Definition #2



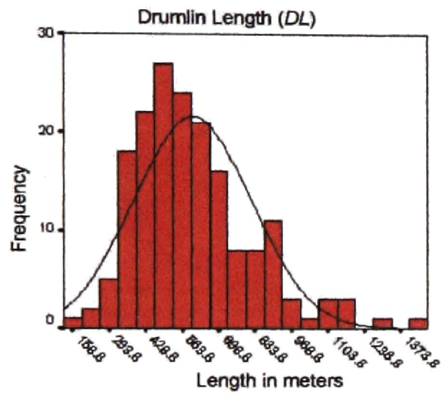



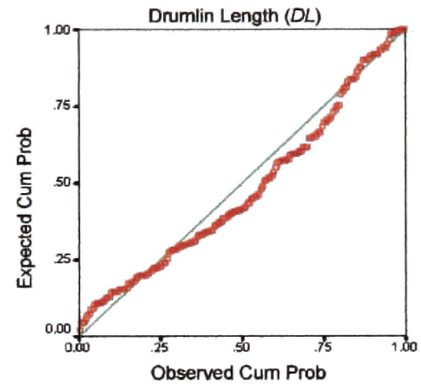



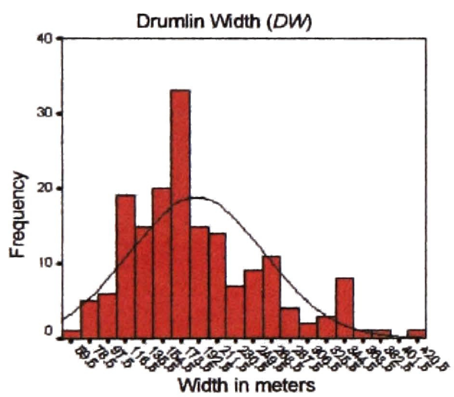



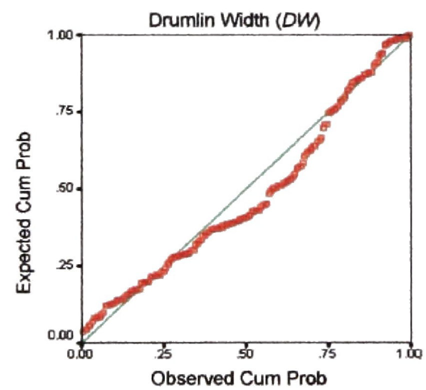
# "NORMAL" HISTOGRAMS & PROBABILITY PLOTS

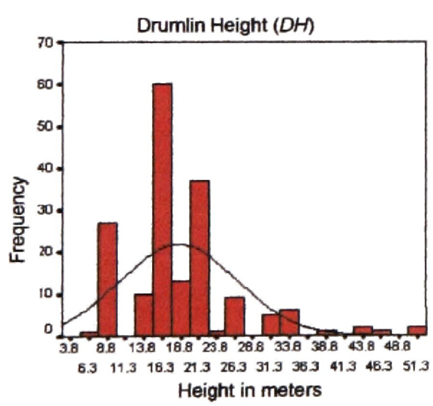
## Tobacco Plains/Stillwater Valley Metrics – Delineation Definition #2

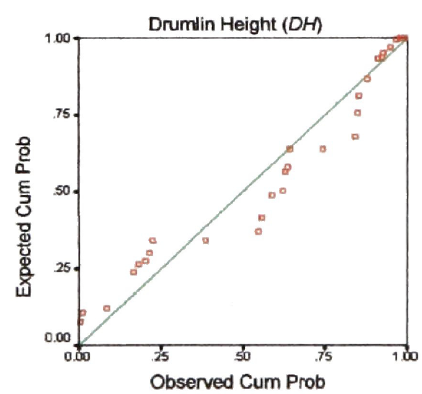


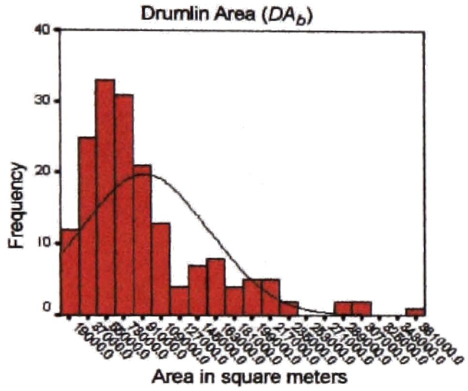



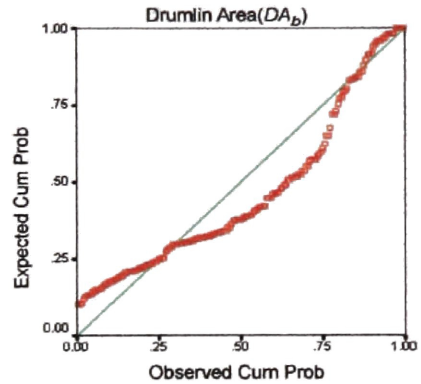



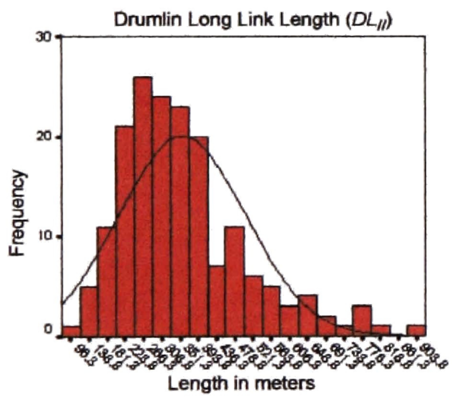



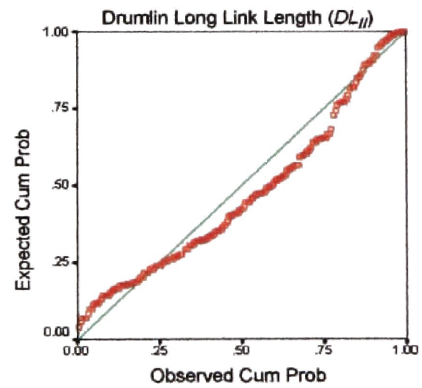
# "NORMAL" HISTOGRAMS & PROBABILITY PLOTS

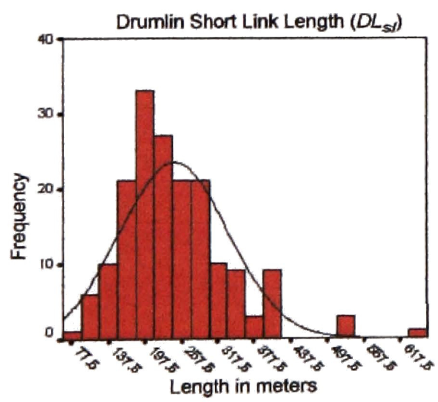
## Tobacco Plains/Stillwater Valley Metrics – Delineation Definition #2

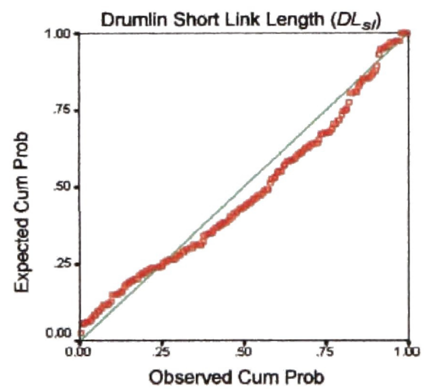


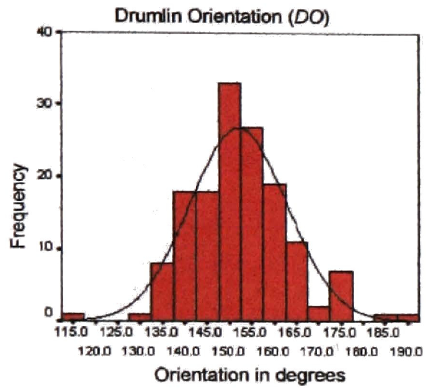



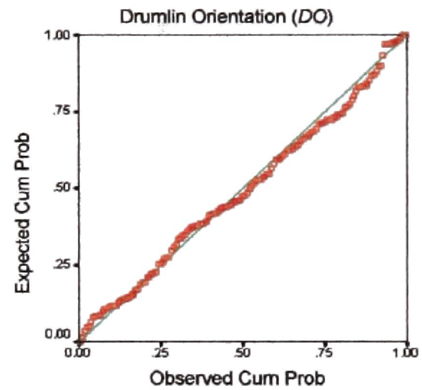



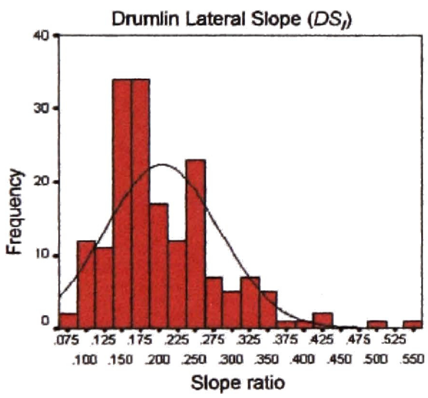



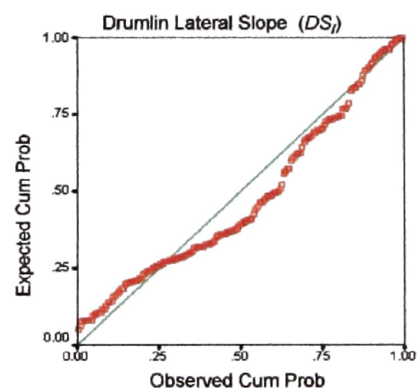
# "NORMAL" HISTOGRAMS & PROBABILITY PLOTS

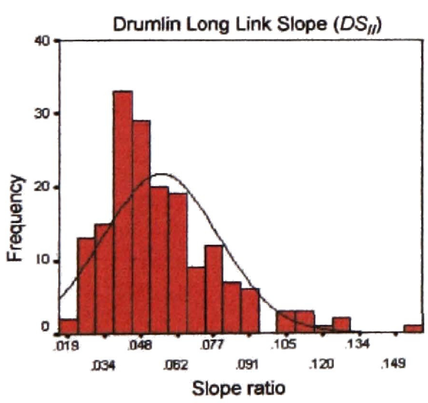
## Tobacco Plains/Stillwater Valley Metrics – Delineation Definition #2

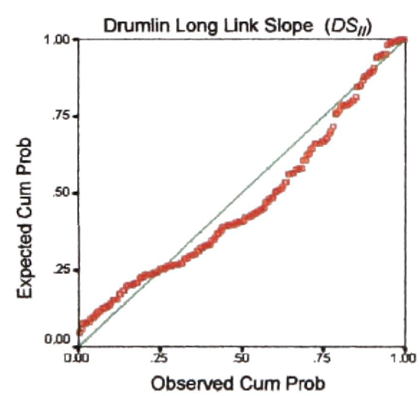


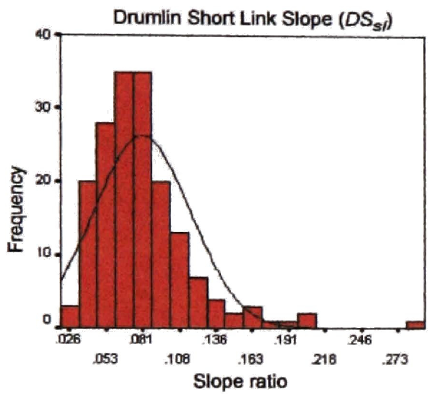



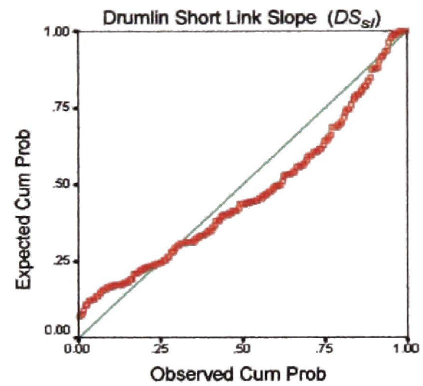



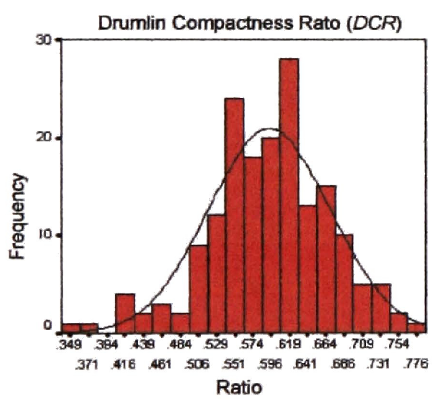



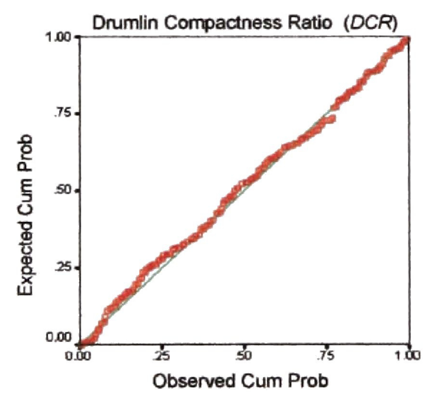
# "NORMAL" HISTOGRAMS & PROBABILITY PLOTS

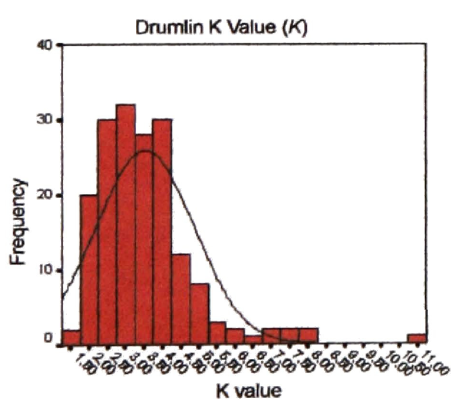
## Tobacco Plains/Stillwater Valley Metrics – Delineation Definition #2

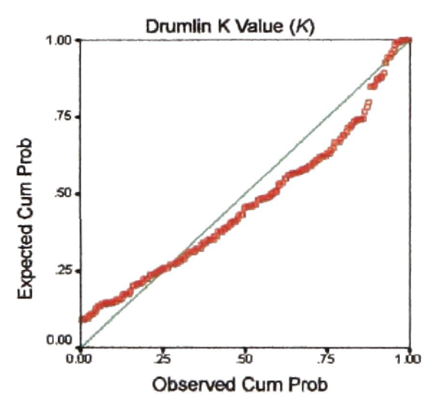


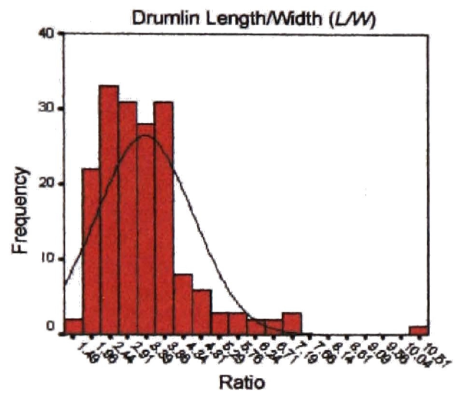



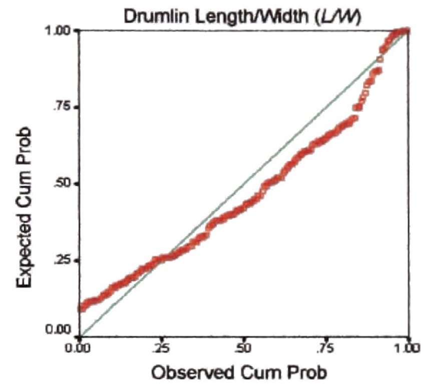



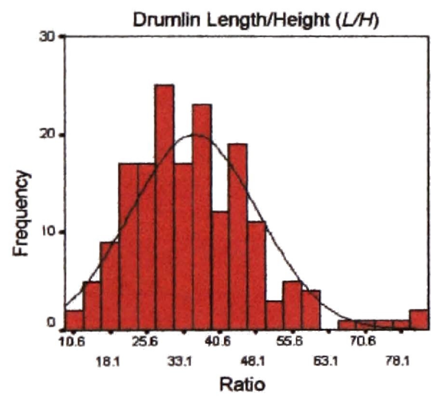



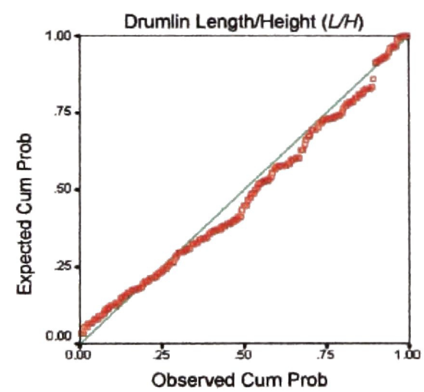
# "NORMAL" HISTOGRAMS & PROBABILITY PLOTS

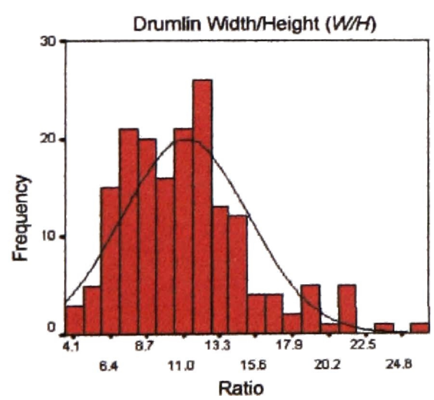
## Tobacco Plains/Stillwater Valley Metrics – Delineation Definition #2

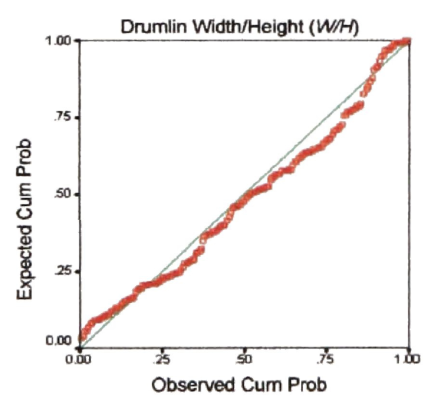


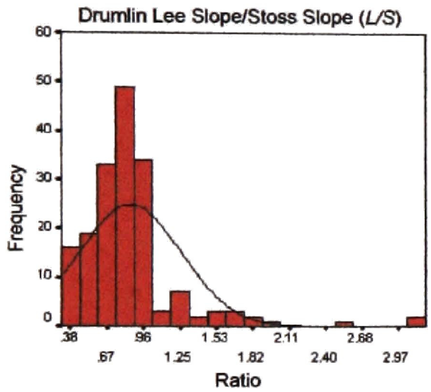



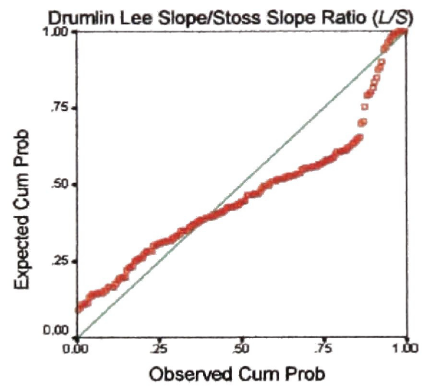



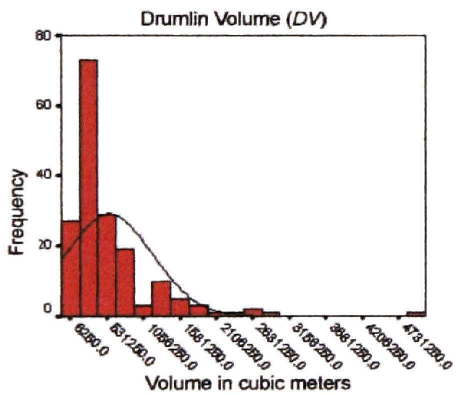



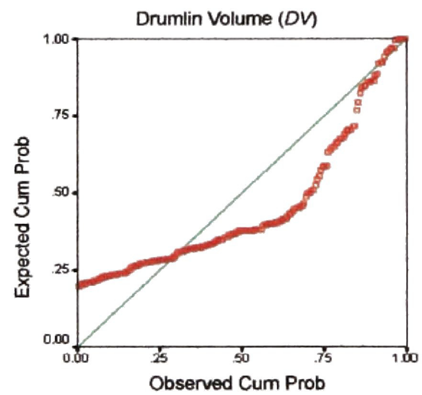
# “NORMAL” HISTOGRAMS & PROBABILITY PLOTS

## Tobacco Plains/Stillwater Valley Metrics – Delineation Definition #2



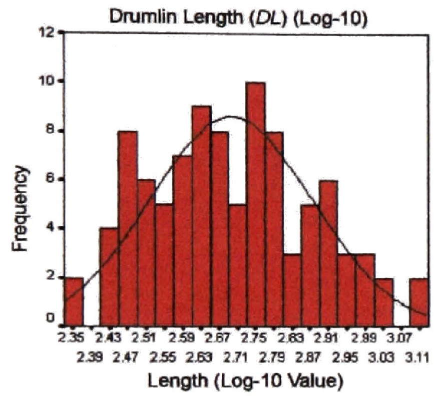
# APPENDIX H

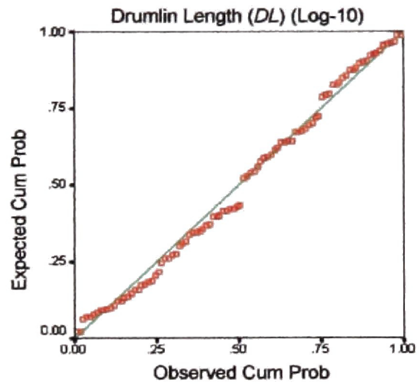
**"Base-10 Logarithmic" Histograms and Probability Plots**

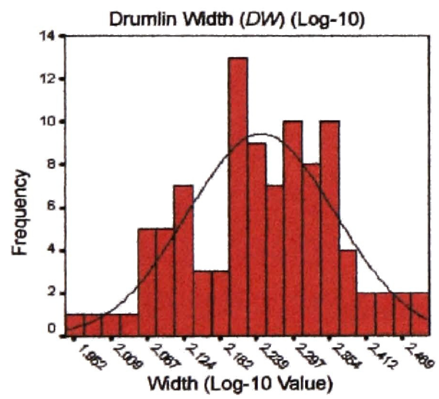
**Delineation Definition #1**

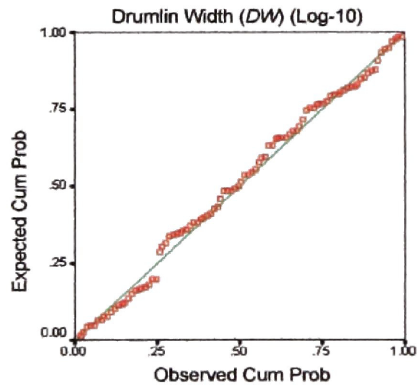
# "BASE-10 LOGARITHMIC" HISTOGRAMS & PROBABILITY PLOTS

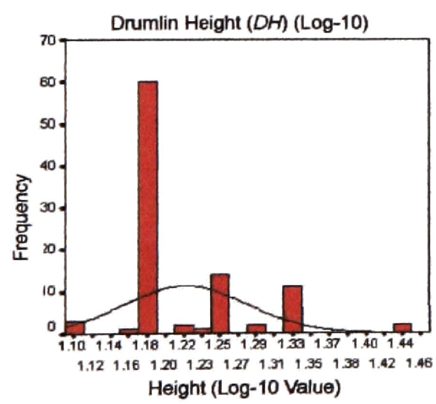
## Seeley/Swan Valley Metrics – Delineation Definition #1

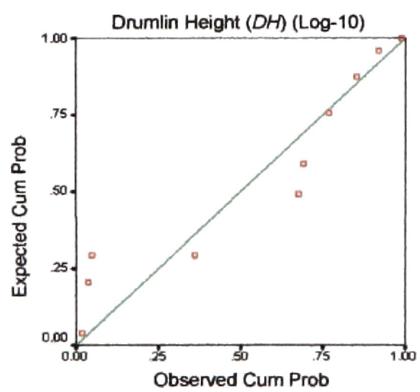


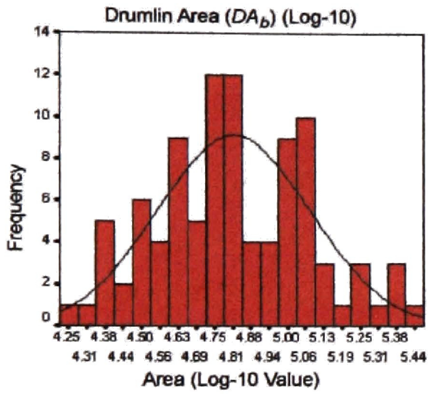



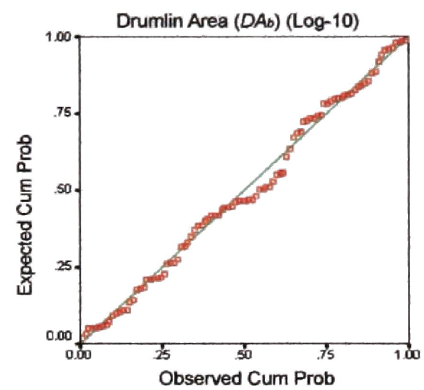



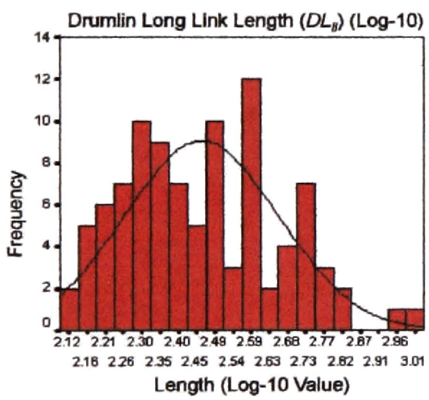



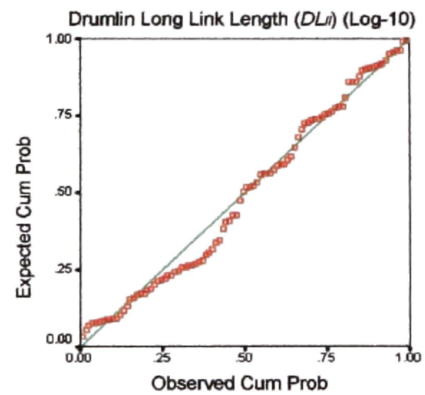
# "BASE-10 LOGARITHMIC" HISTOGRAMS & PROBABILITY PLOTS

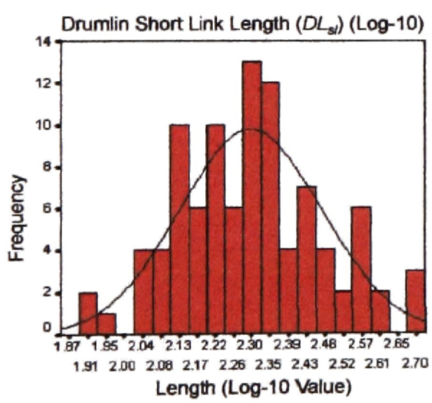
## Seeley/Swan Valley Metrics – Delineation Definition #1

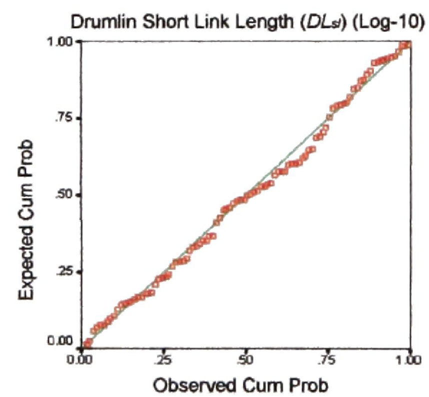


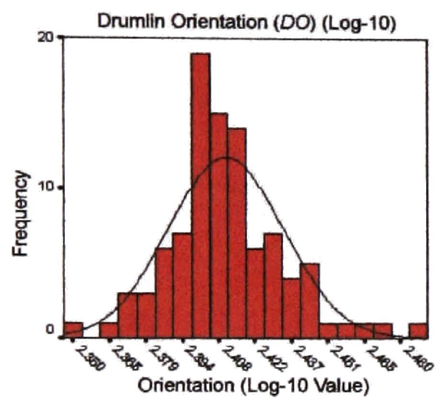



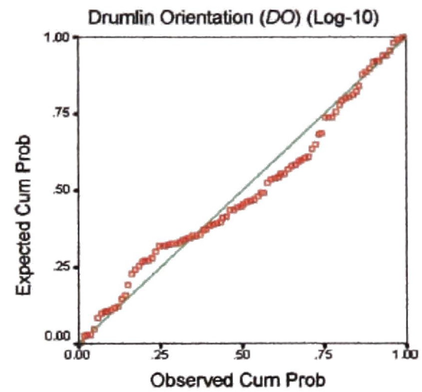



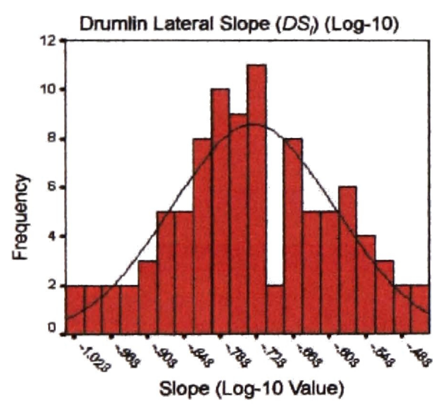



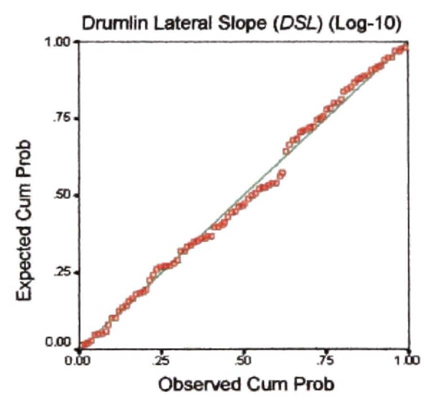
# "BASE-10 LOGARITHMIC" HISTOGRAMS & PROBABILITY PLOTS

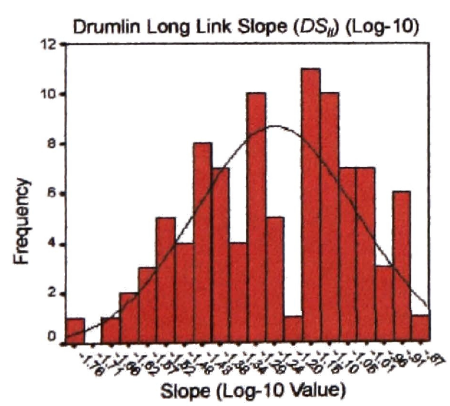
## Seeley/Swan Valley Metrics – Delineation Definition #1

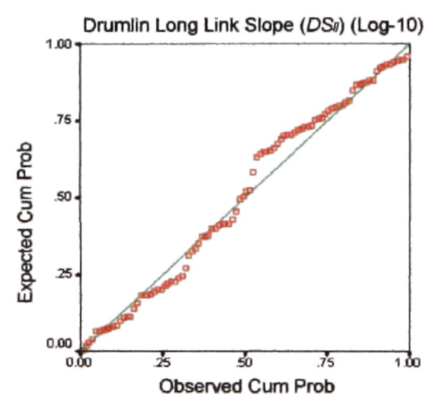


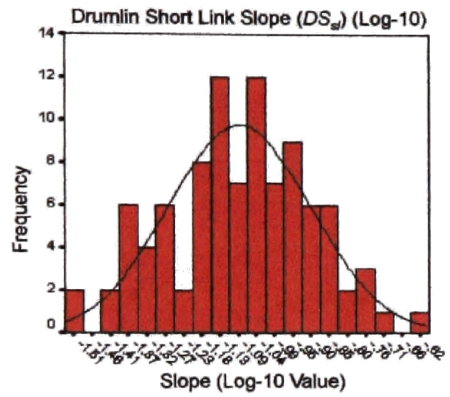



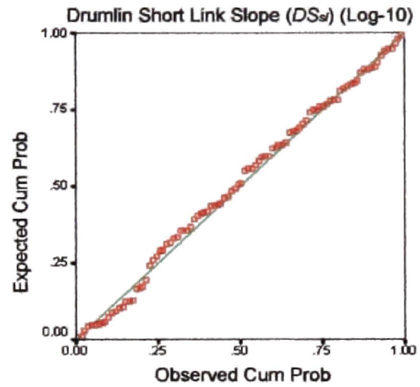



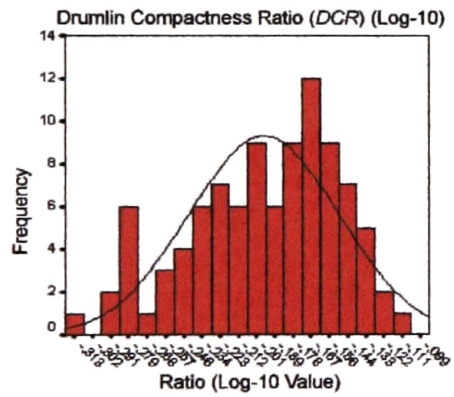



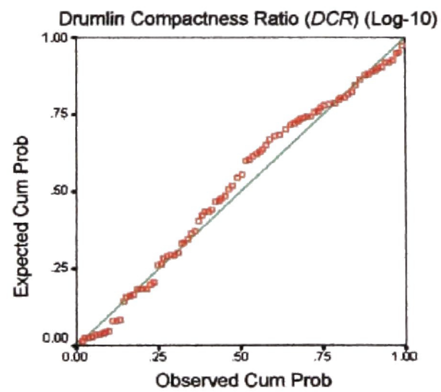
# "BASE-10 LOGARITHMIC" HISTOGRAMS & PROBABILITY PLOTS

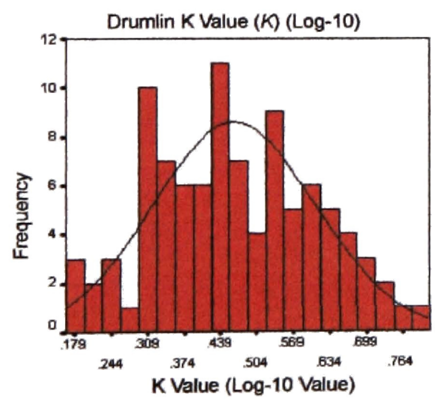
## Seeley/Swan Valley Metrics – Delineation Definition #1

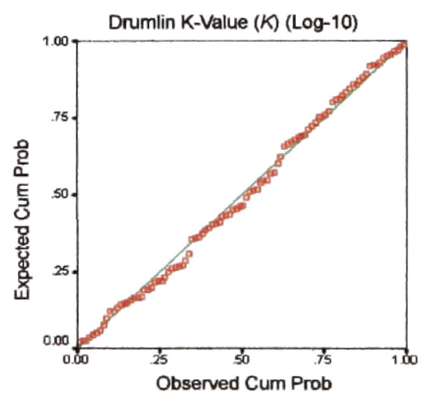


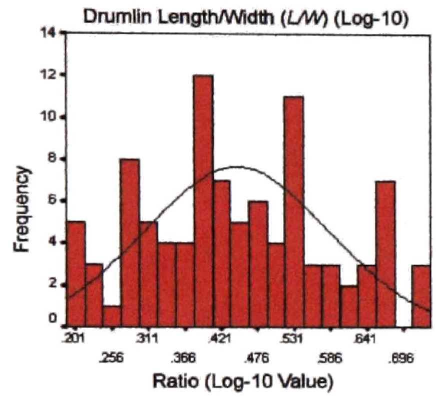



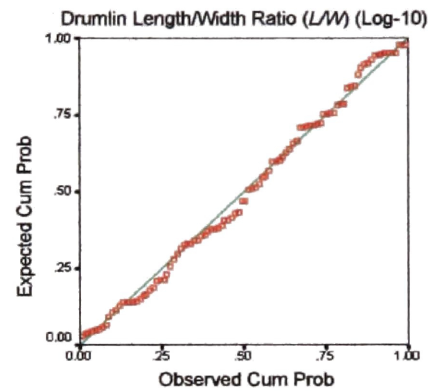



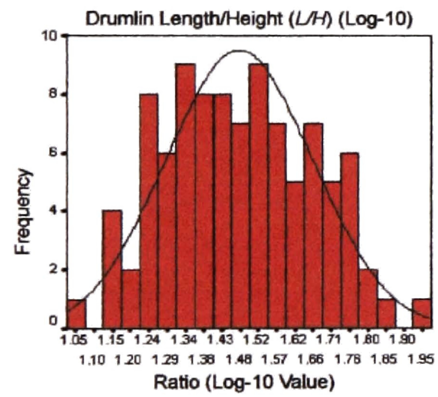



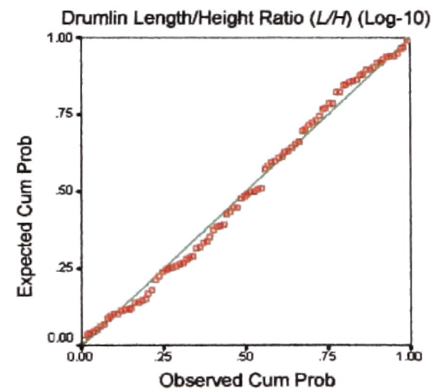
# "BASE-10 LOGARITHMIC" HISTOGRAMS & PROBABILITY PLOTS

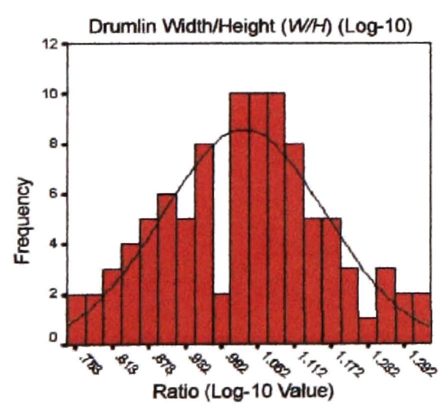
## Seeley/Swan Valley Metrics – Delineation Definition #1

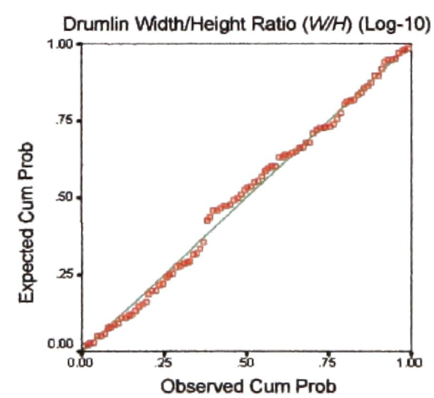


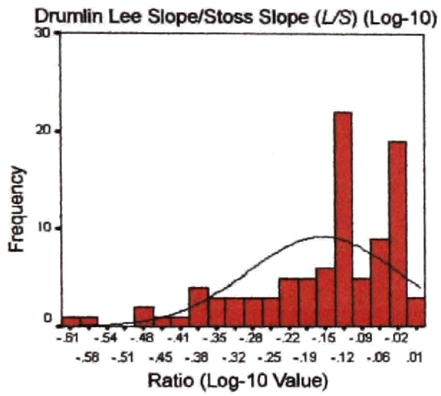



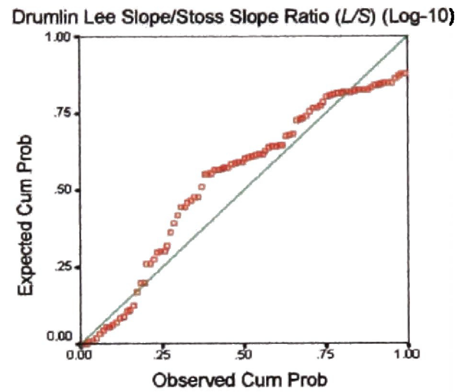



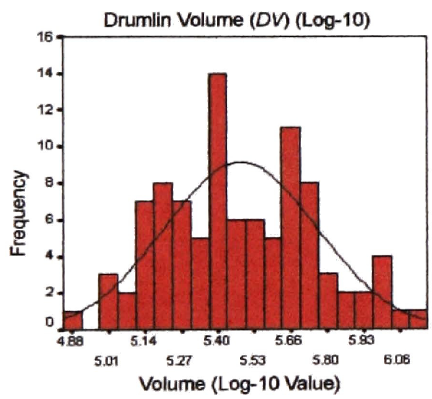



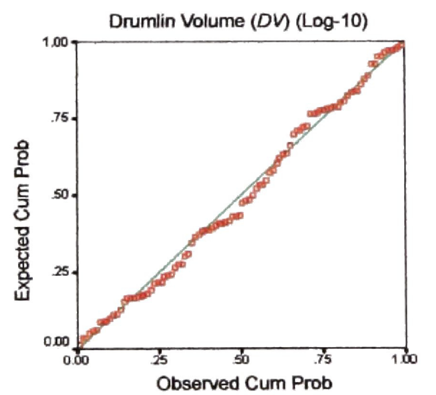
# "BASE-10 LOGARITHMIC" HISTOGRAMS & PROBABILITY PLOTS

## Seeley/Swan Valley Metrics – Delineation Definition #1



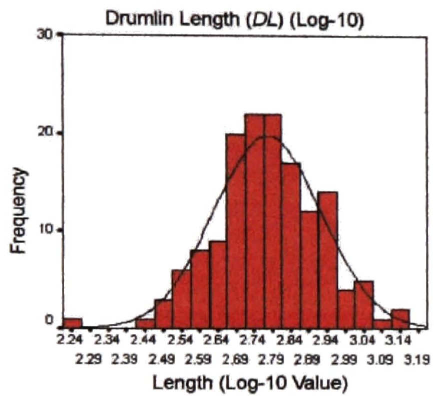



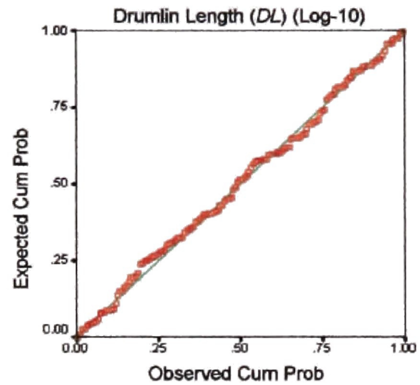



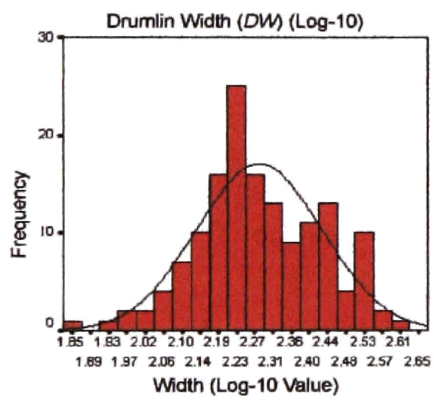



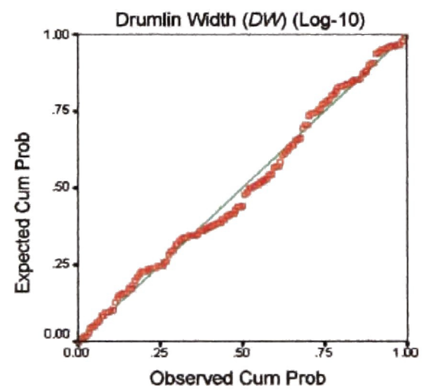
# "BASE-10 LOGARITHMIC" HISTOGRAMS & PROBABILITY PLOTS

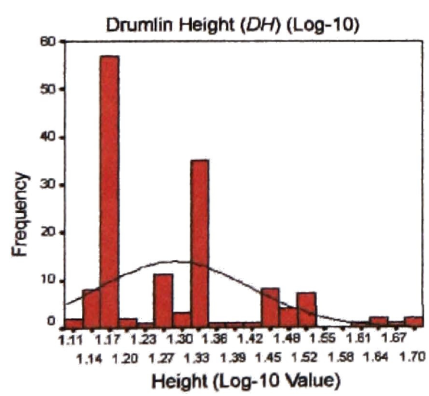
## Tobacco Plains/Stillwater Valley Metrics – Delineation Definition #1

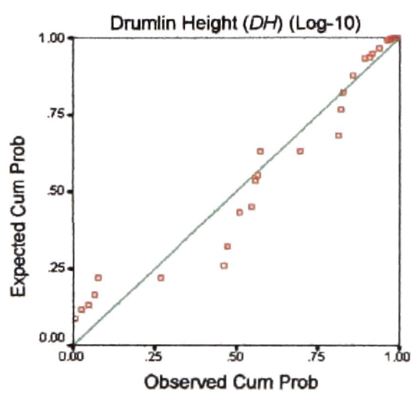


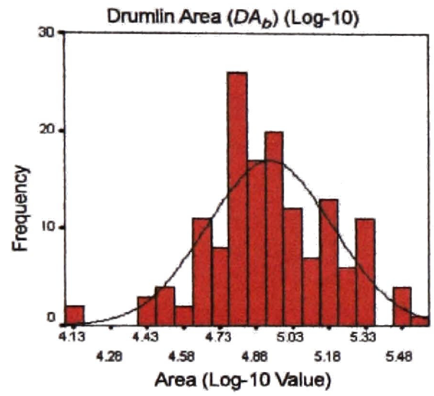



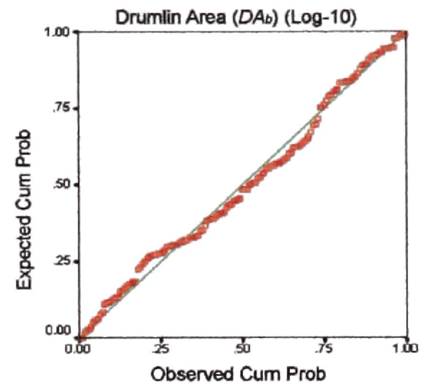



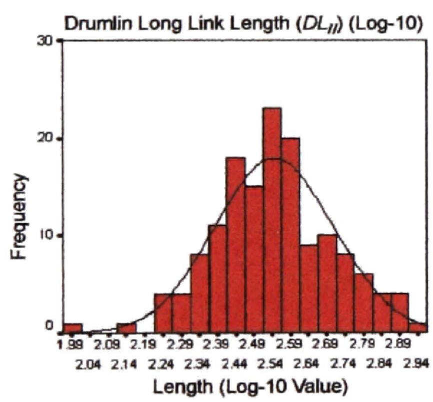



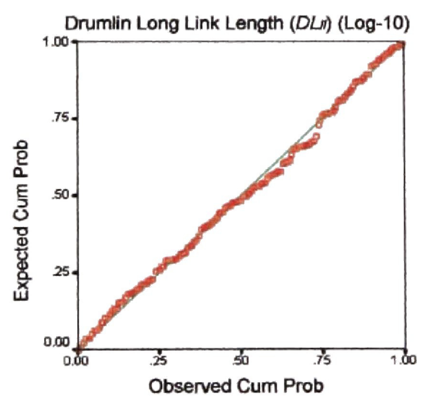
# "BASE-10 LOGARITHMIC" HISTOGRAMS & PROBABILITY PLOTS

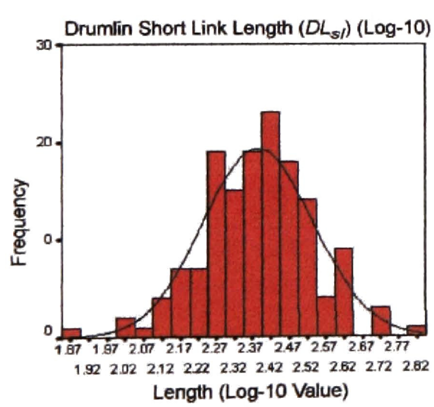
## Tobacco Plains/Stillwater Valley Metrics – Delineation Definition #1

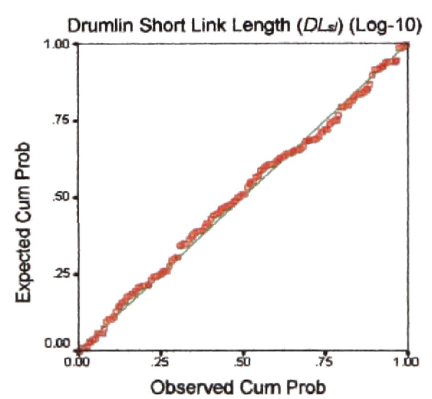


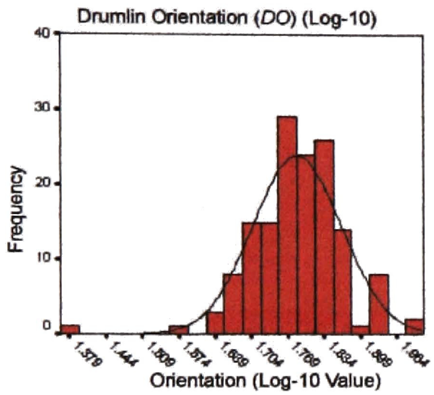



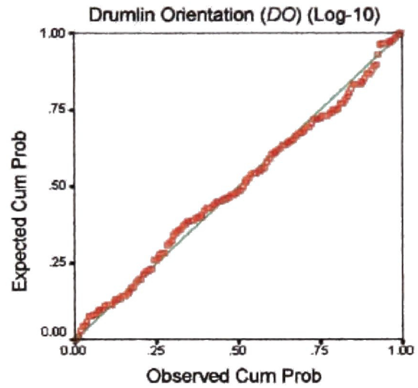



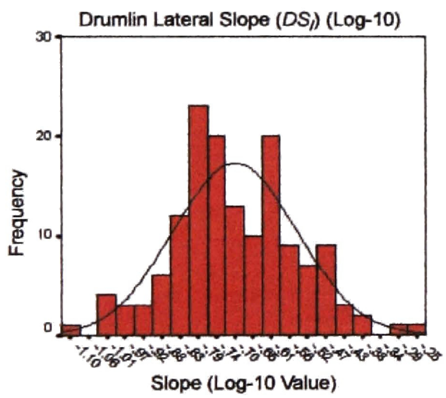



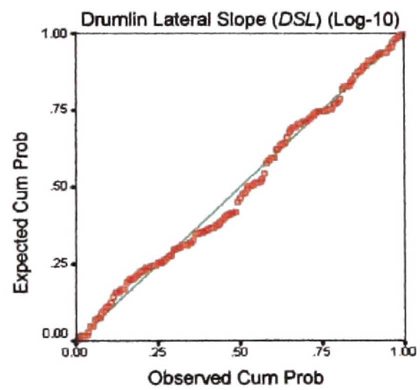
# "BASE-10 LOGARITHMIC" HISTOGRAMS & PROBABILITY PLOTS

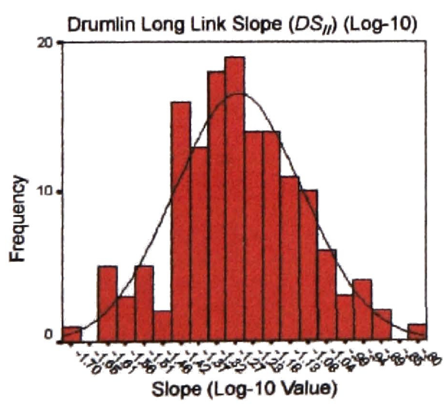
## Tobacco Plains/Stillwater Valley Metrics – Delineation Definition #1

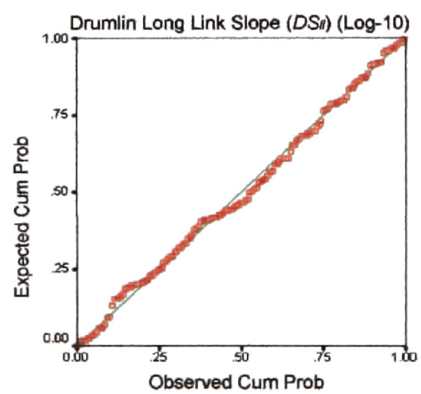


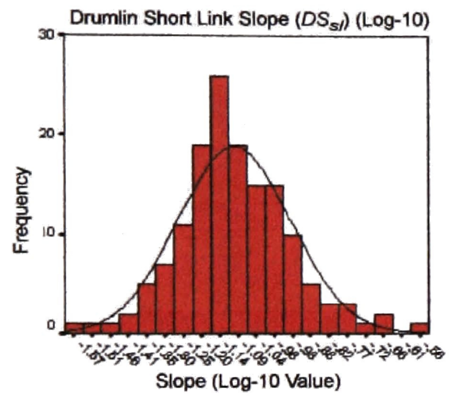



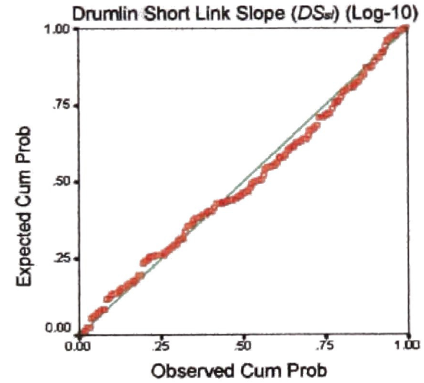



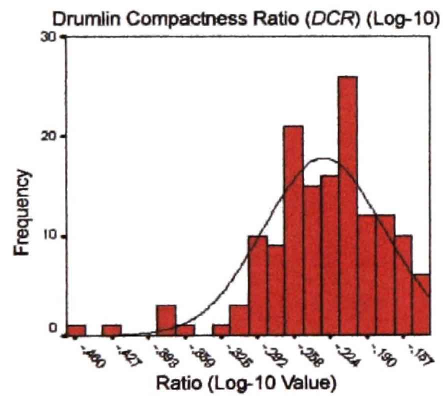



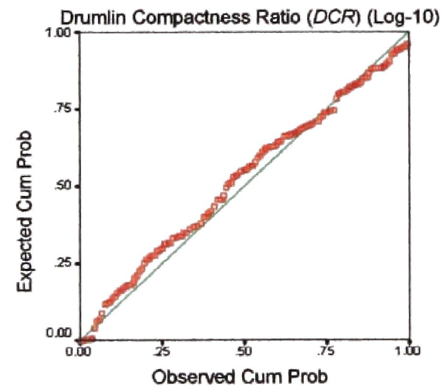
## “BASE-10 LOGARITHMIC” HISTOGRAMS & PROBABILITY PLOTS

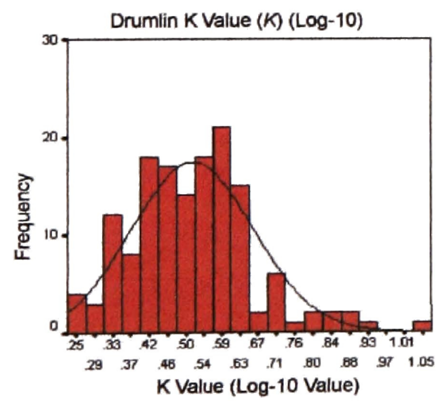
### Tobacco Plains/Stillwater Valley Metrics – Delineation Definition #1

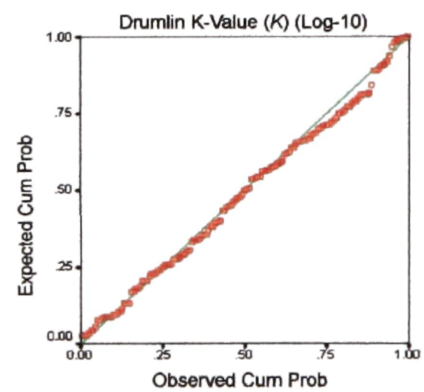


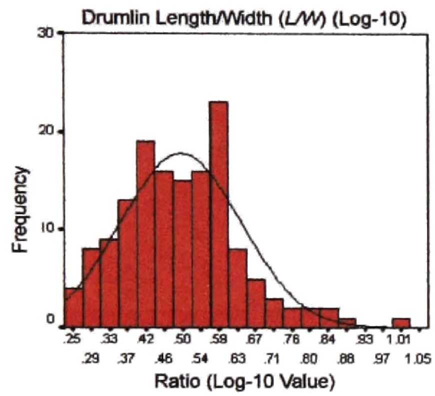



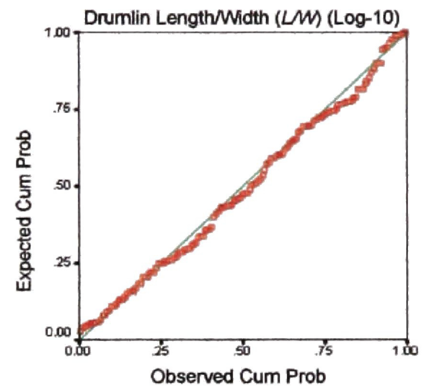



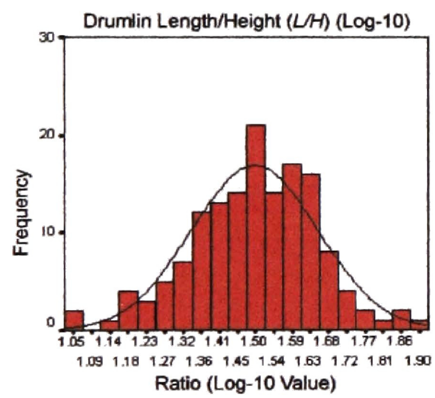



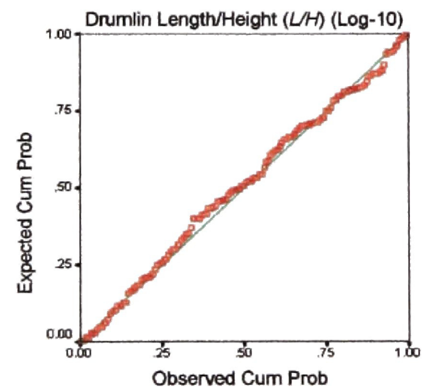
# "BASE-10 LOGARITHMIC" HISTOGRAMS & PROBABILITY PLOTS

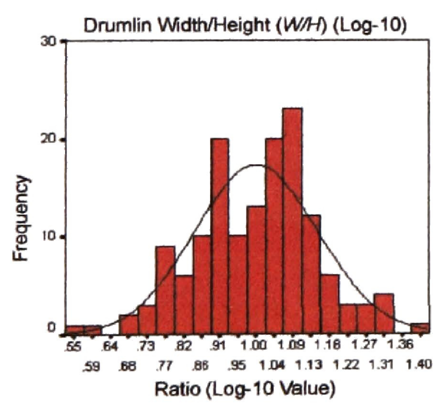
## Tobacco Plains/Stillwater Valley Metrics – Delineation Definition #1

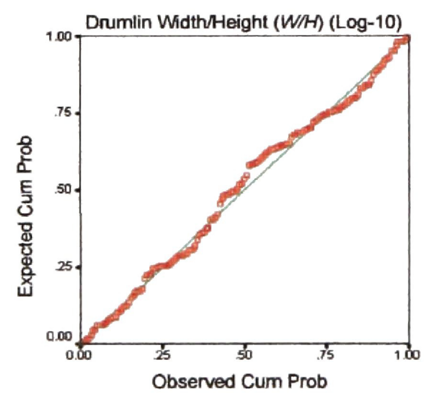


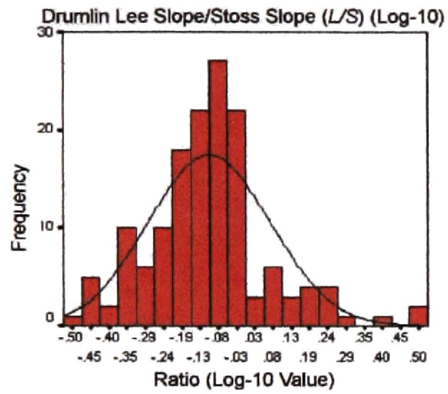



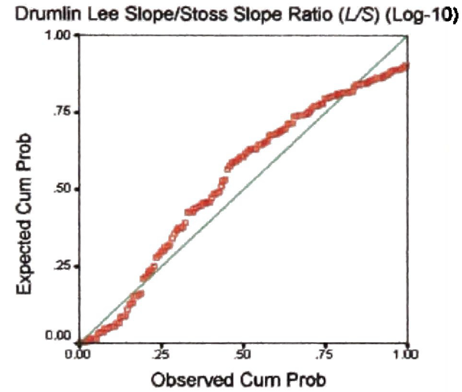



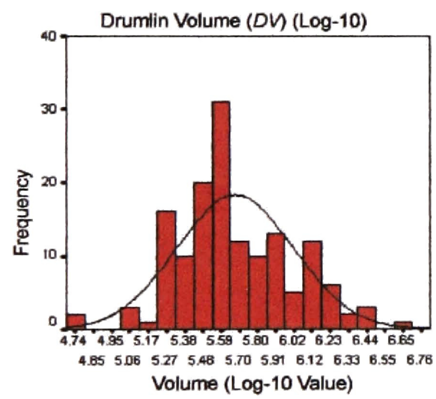



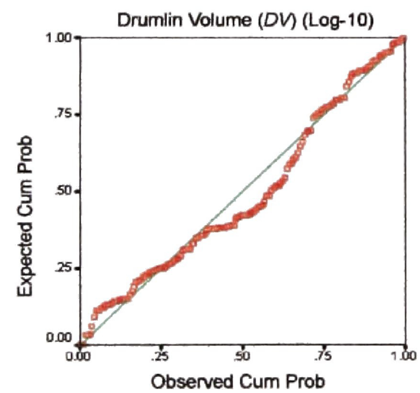
# "BASE-10 LOGARITHMIC" HISTOGRAMS & PROBABILITY PLOTS

## Tobacco Plains/Stillwater Valley Metrics – Delineation Definition #1



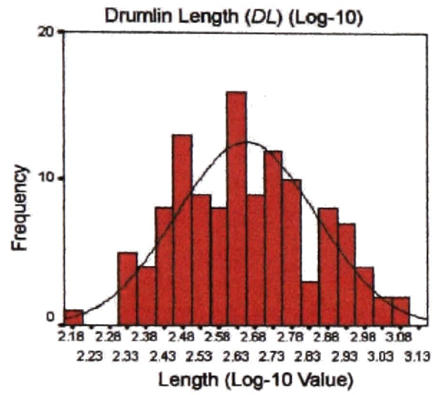
# APPENDIX I

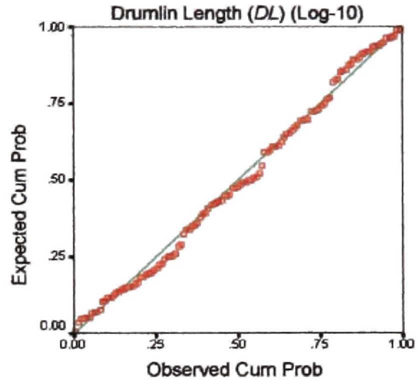
**"Base-10 Logarithmic" Histograms and Probability Plots**

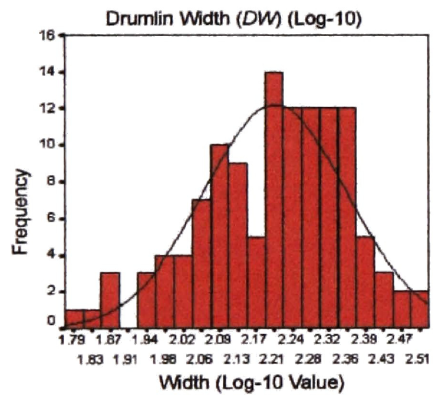
**Delineation Definition #2**

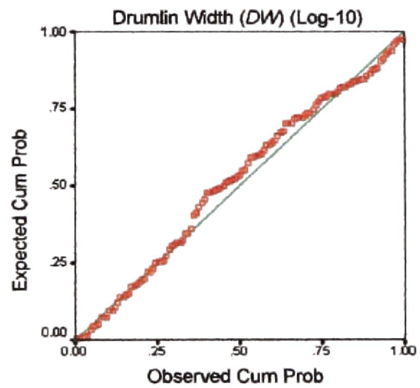
# "BASE-10 LOGARITHMIC" HISTOGRAMS & PROBABILITY PLOTS

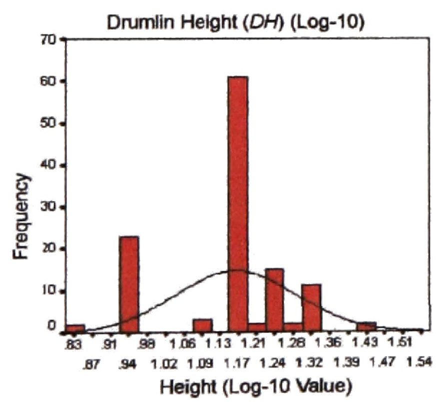
## Seeley/Swan Valley Metrics – Delineation Definition #2

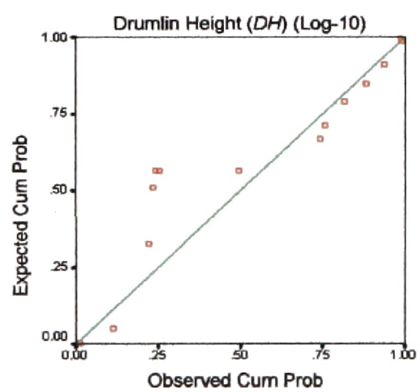


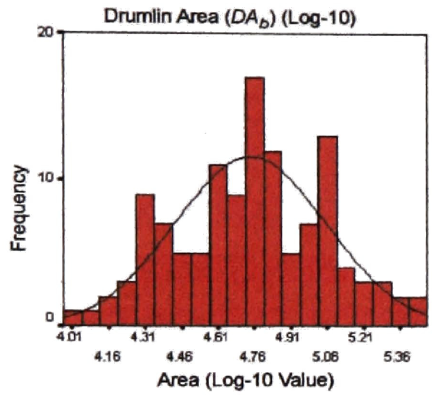



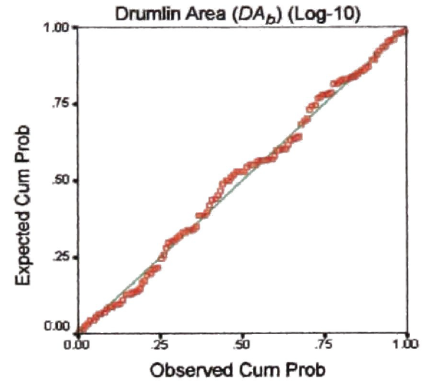



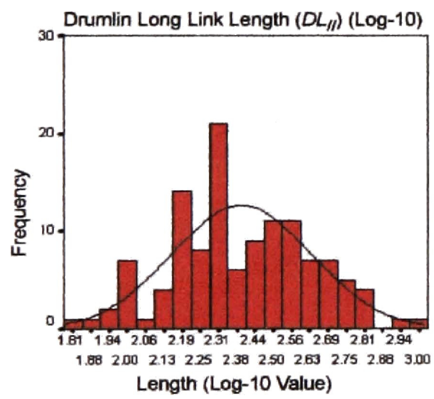



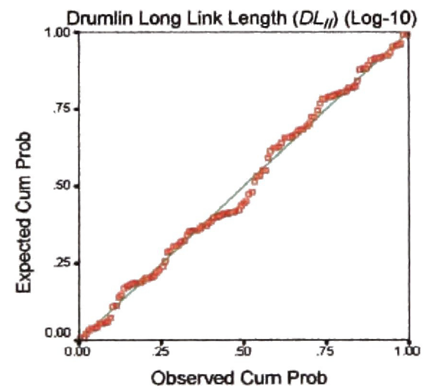
# "BASE-10 LOGARITHMIC" HISTOGRAMS & PROBABILITY PLOTS

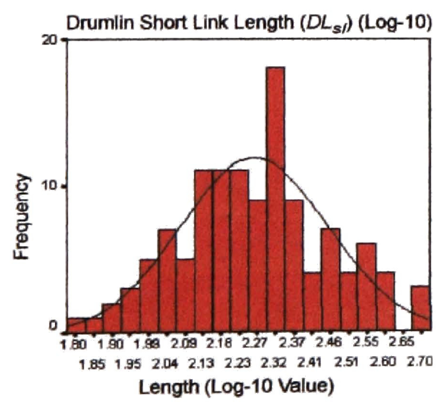
## Seeley/Swan Valley Metrics – Delineation Definition #2

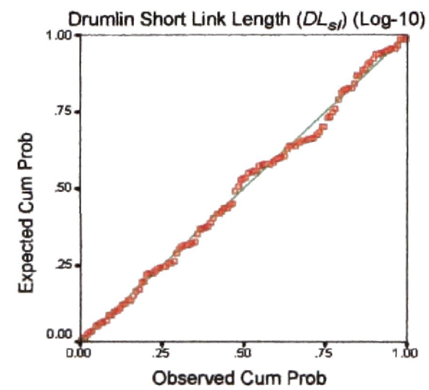


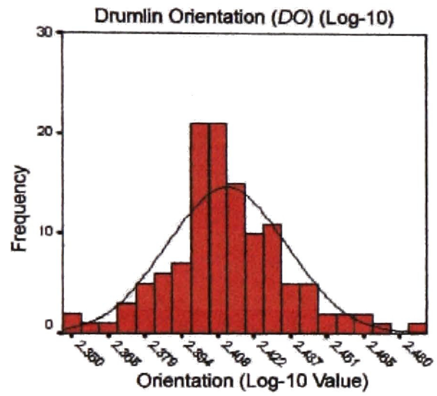



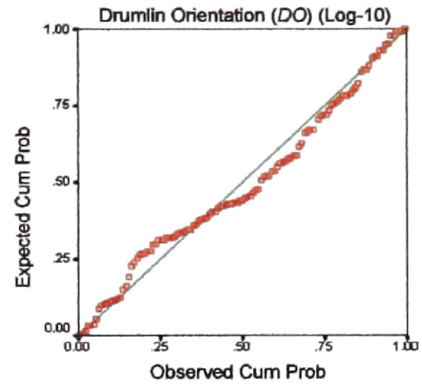



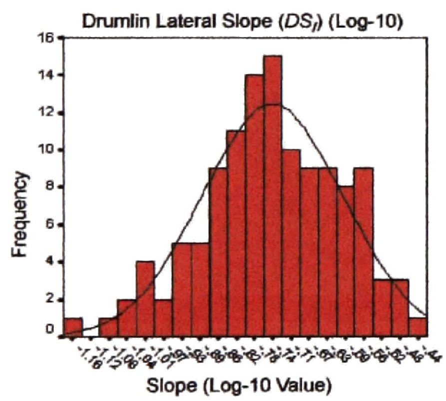



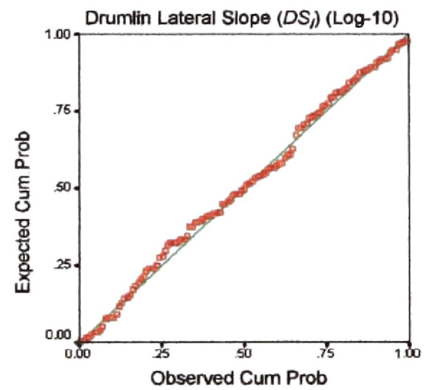
# "BASE-10 LOGARITHMIC" HISTOGRAMS & PROBABILITY PLOTS

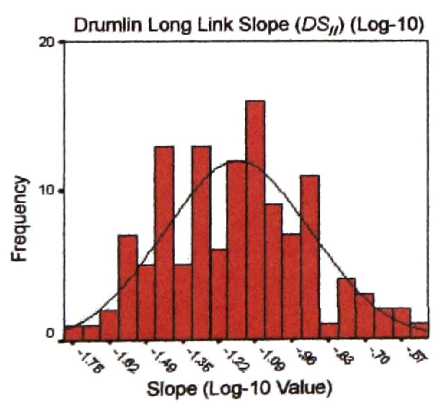
## Seeley/Swan Valley Metrics – Delineation Definition #2

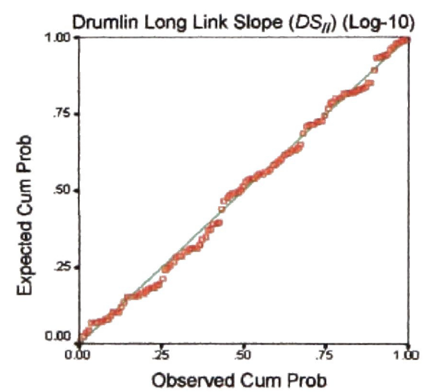


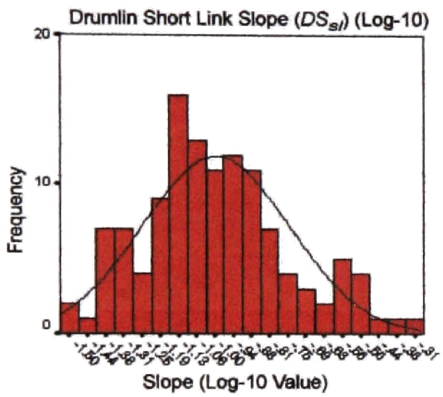



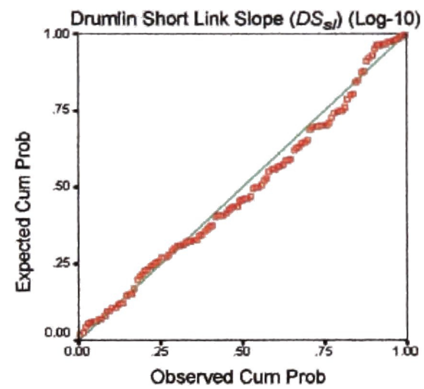



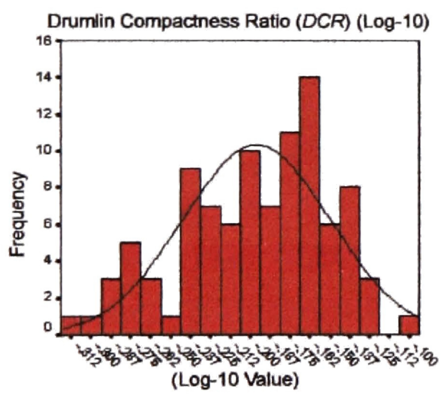



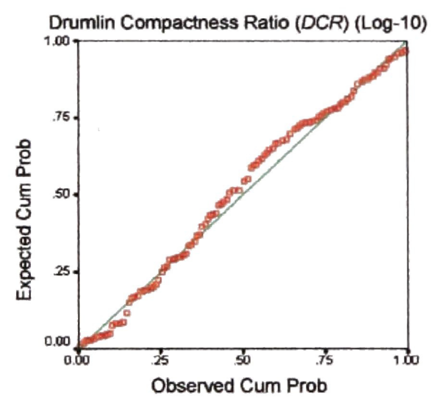
# "BASE-10 LOGARITHMIC" HISTOGRAMS & PROBABILITY PLOTS

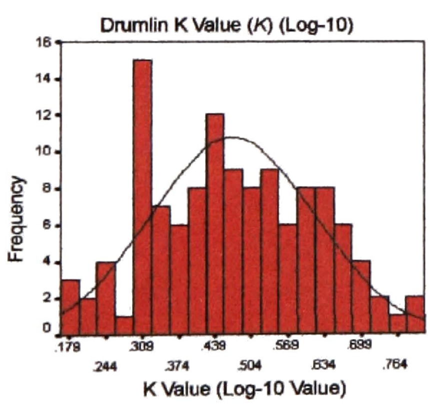
## Seeley/Swan Valley Metrics – Delineation Definition #2

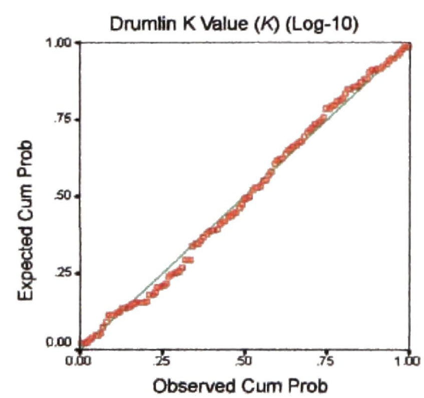


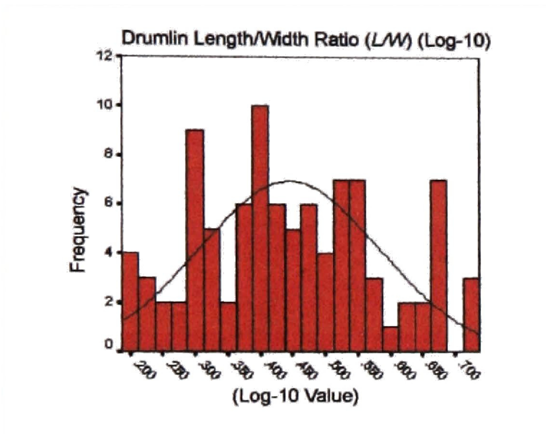



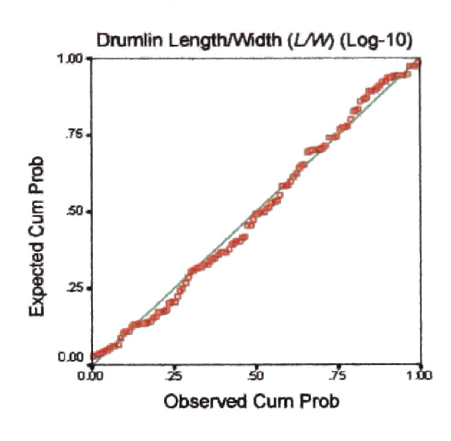



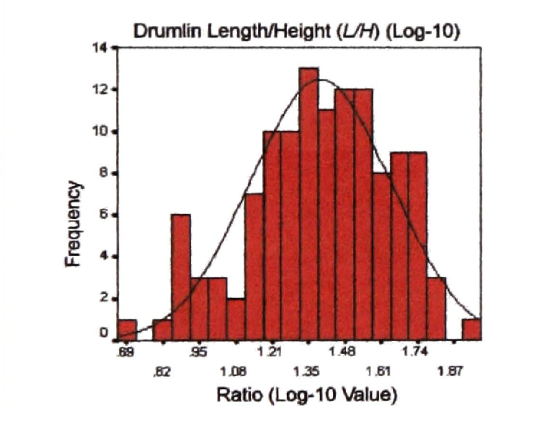



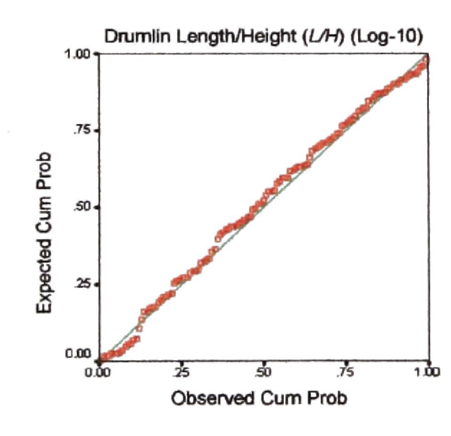
# "BASE-10 LOGARITHMIC" HISTOGRAMS & PROBABILITY PLOTS

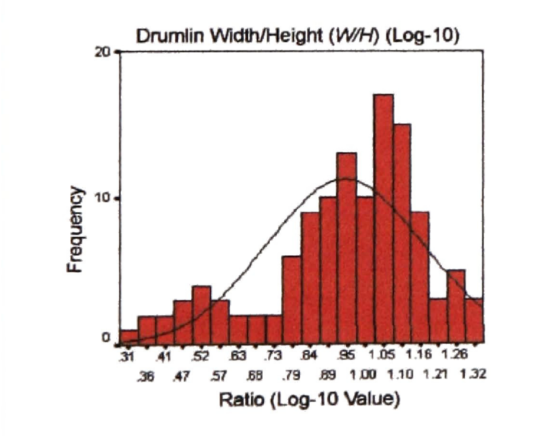
## Seeley/Swan Valley Metrics – Delineation Definition #2

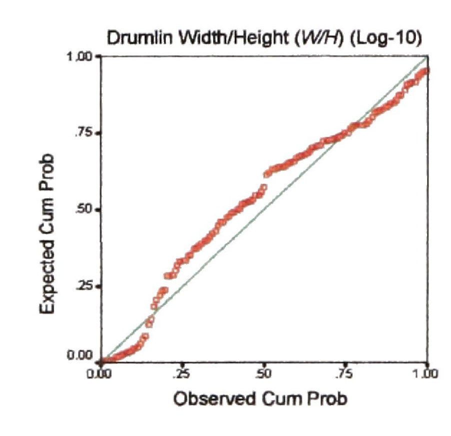


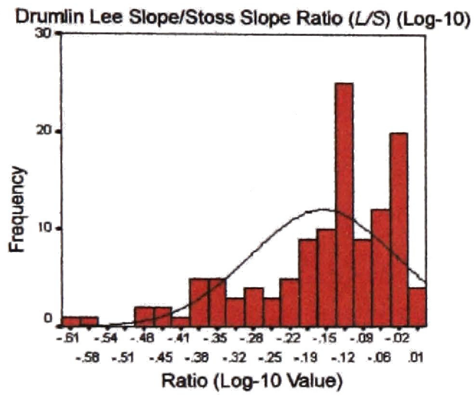



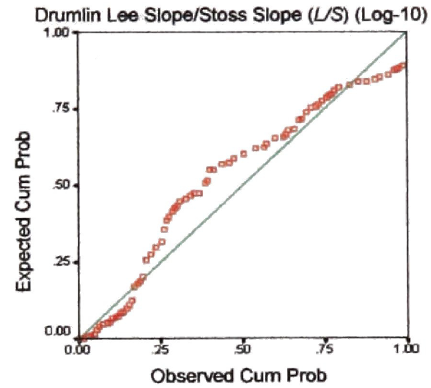



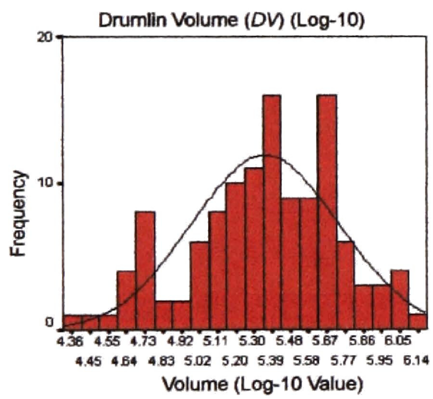



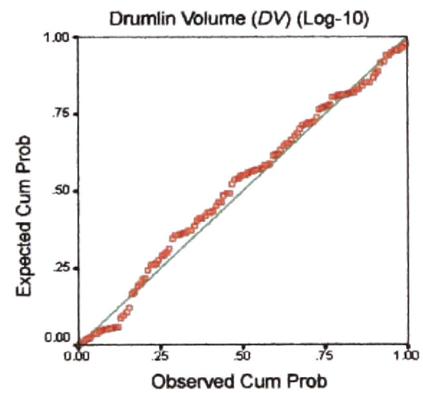
# "BASE-10 LOGARITHMIC" HISTOGRAMS & PROBABILITY PLOTS

## Seeley/Swan Valley Metrics – Delineation Definition #2



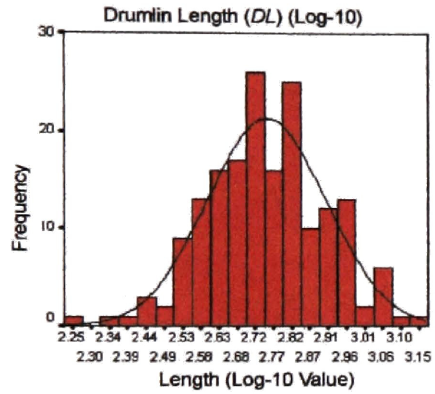



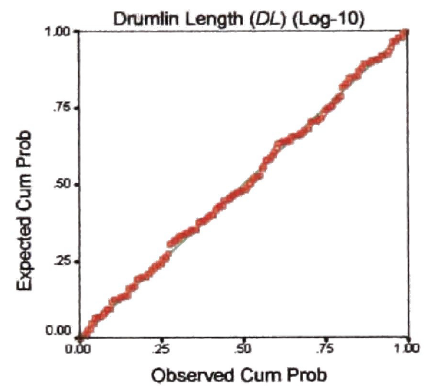



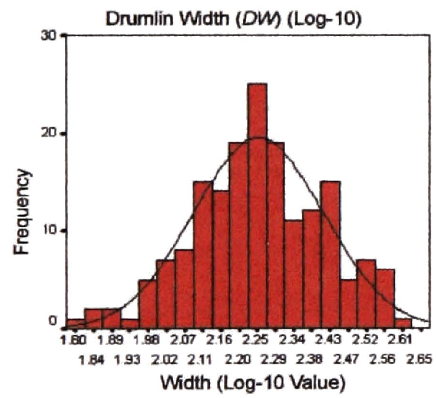



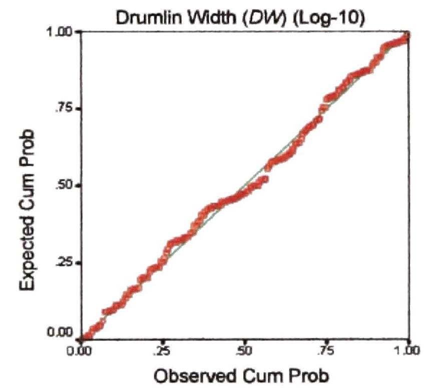
## “BASE-10 LOGARITHMIC” HISTOGRAMS & PROBABILITY PLOTS

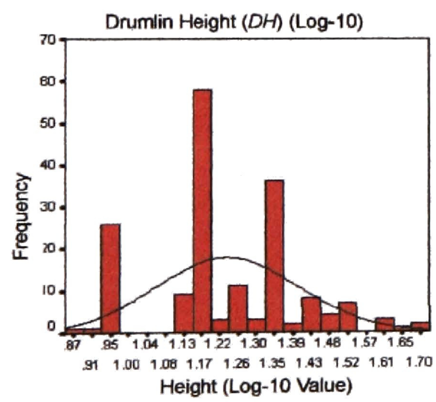
### Tobacco Plains/Stillwater Valley Metrics – Delineation Definition #2

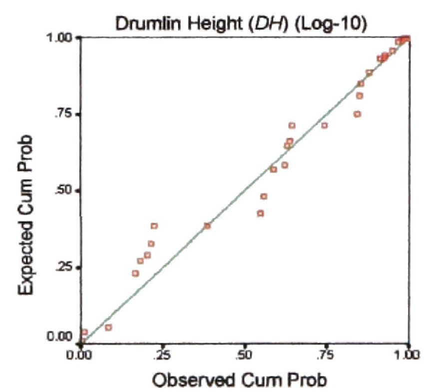


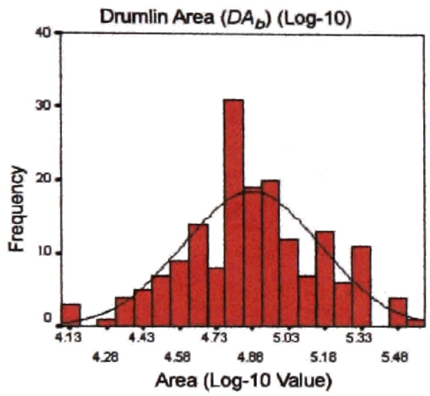



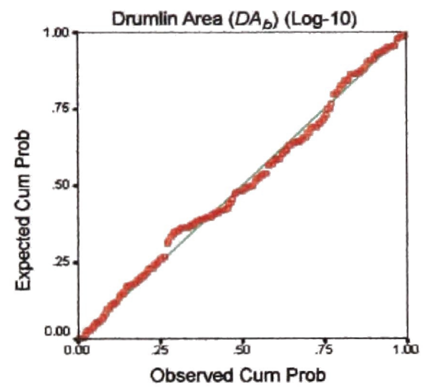



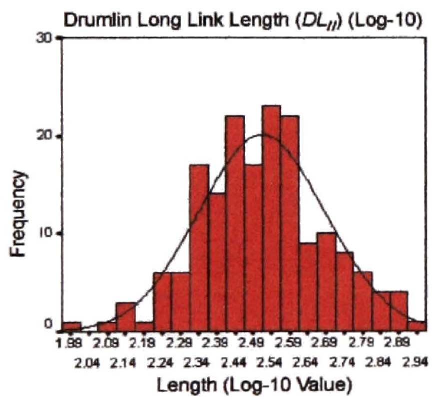



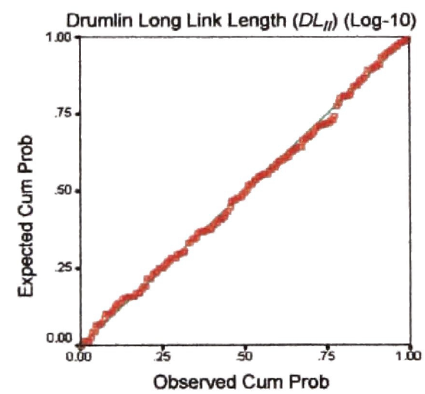
# “BASE-10 LOGARITHMIC” HISTOGRAMS & PROBABILITY PLOTS

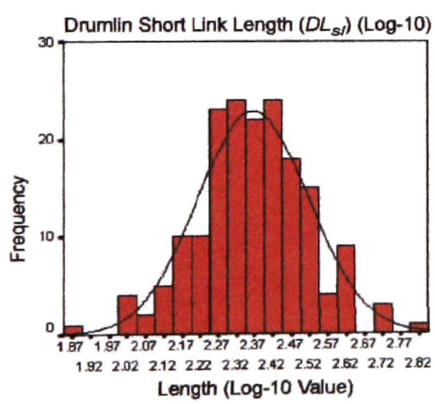
## Tobacco Plains/Stillwater Valley Metrics – Delineation Definition #2

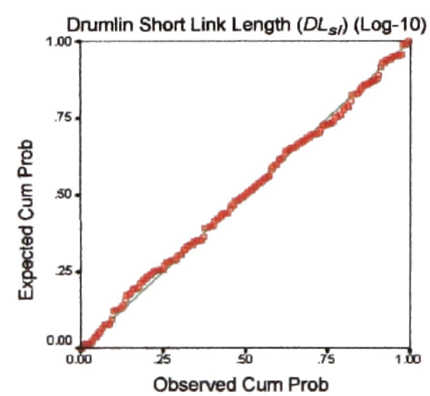


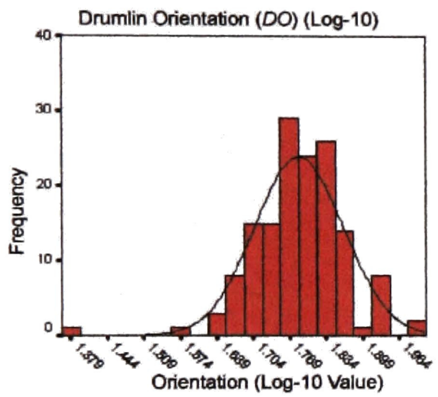



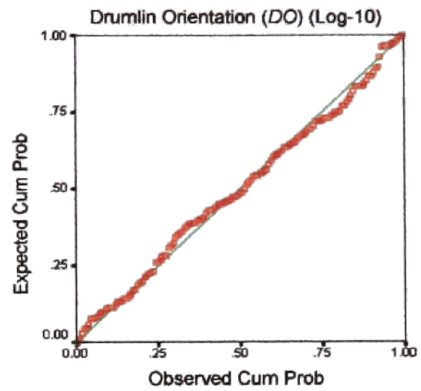



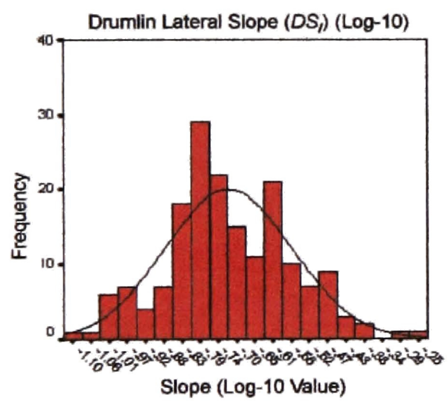



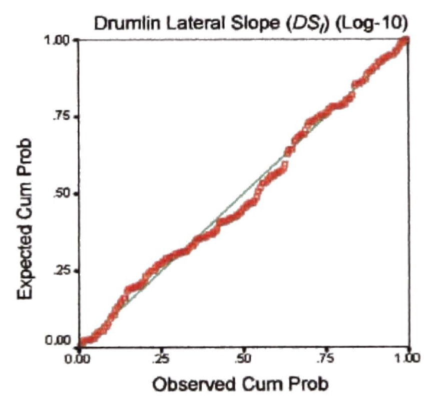
# "BASE-10 LOGARITHMIC" HISTOGRAMS & PROBABILITY PLOTS

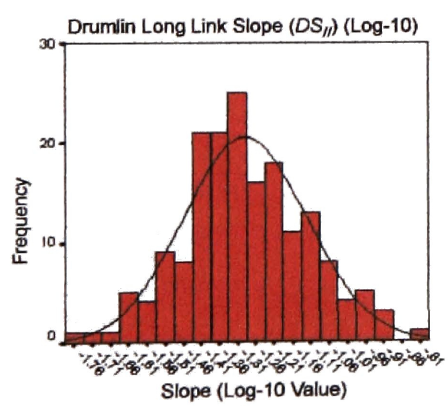
## Tobacco Plains/Stillwater Valley Metrics – Delineation Definition #2

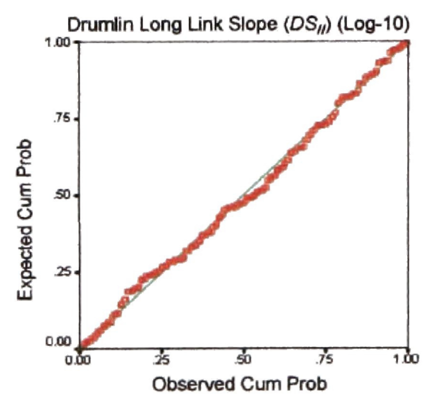


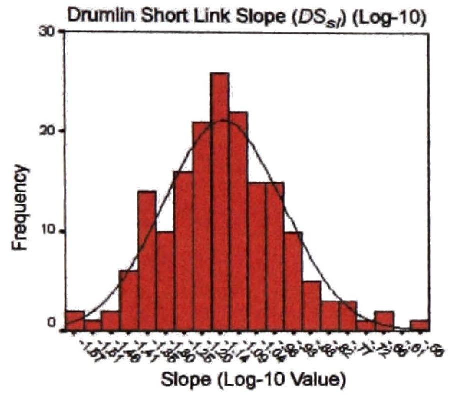



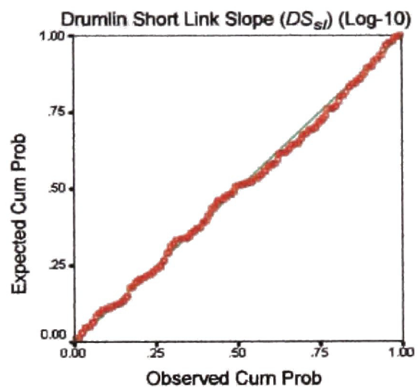



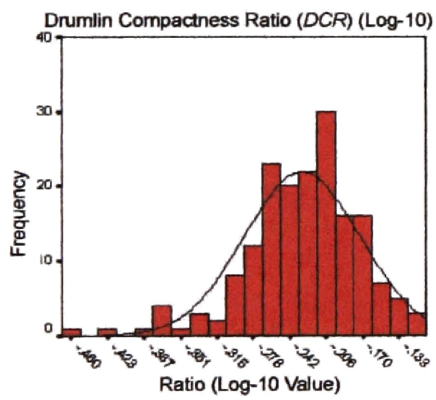



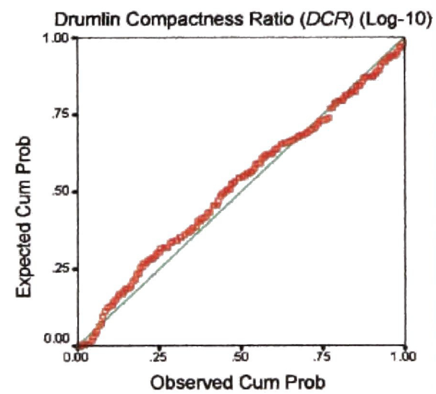
# “BASE-10 LOGARITHMIC” HISTOGRAMS & PROBABILITY PLOTS

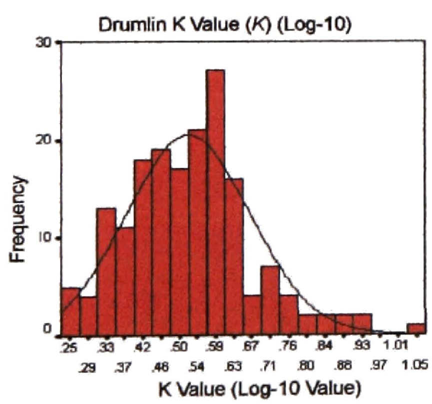
## Tobacco Plains/Stillwater Valley Metrics – Delineation Definition #2

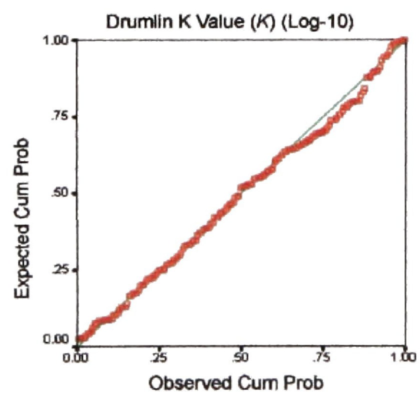


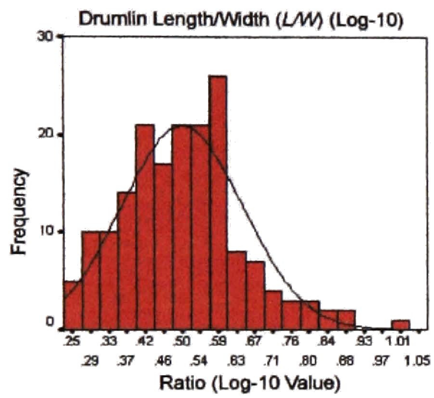



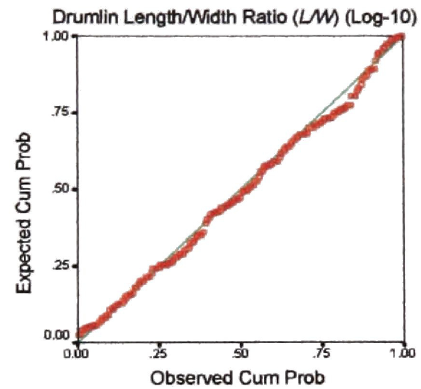



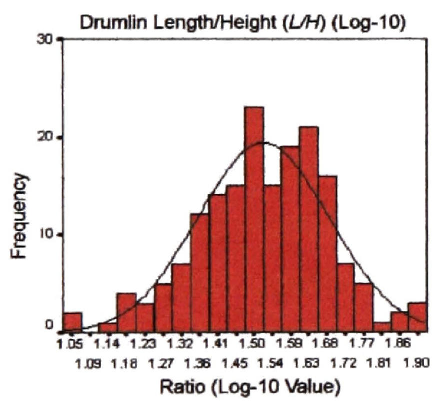



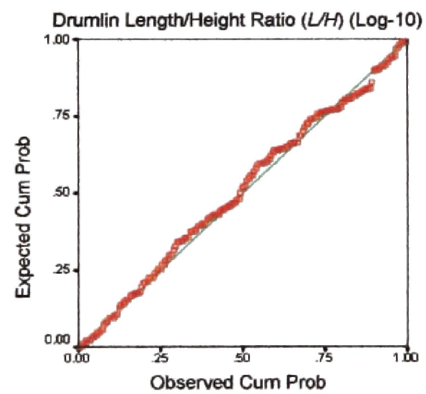
## "BASE-10 LOGARITHMIC" HISTOGRAMS & PROBABILITY PLOTS

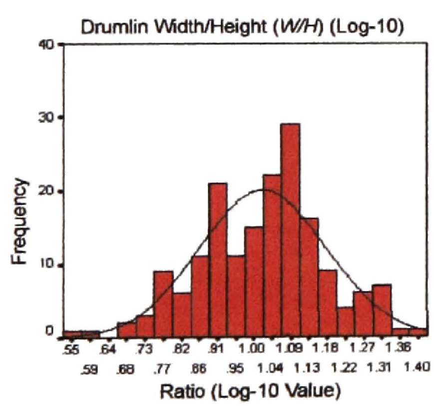
### Tobacco Plains/Stillwater Valley Metrics – Delineation Definition #2

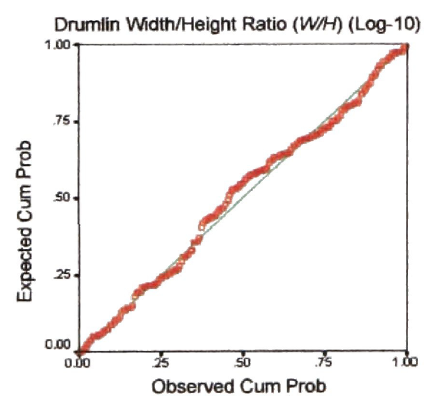


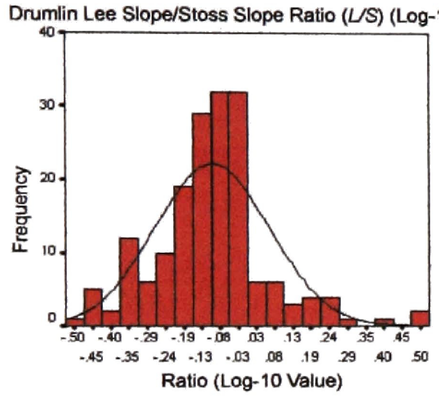



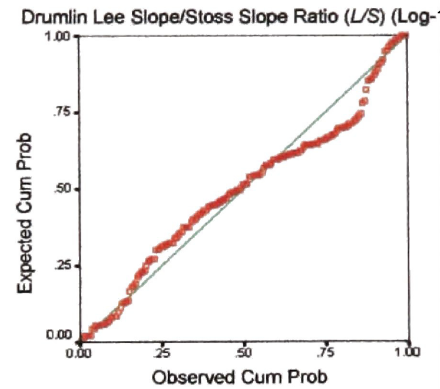



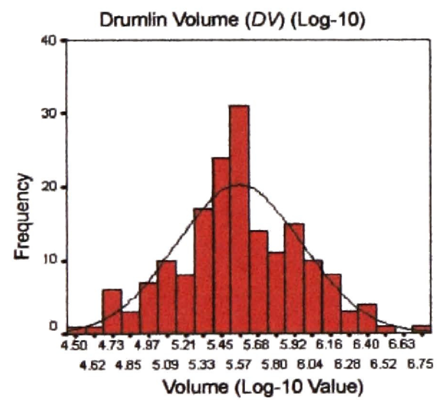



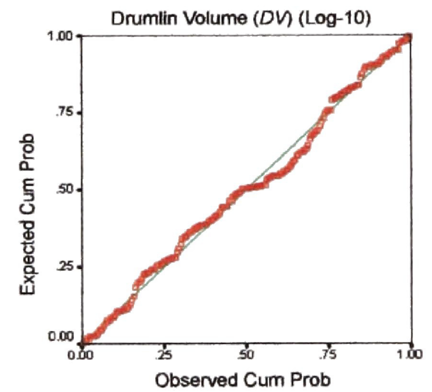
# "BASE-10 LOGARITHMIC" HISTOGRAMS & PROBABILITY PLOTS

## Tobacco Plains/Stillwater Valley Metrics – Delineation Definition #2



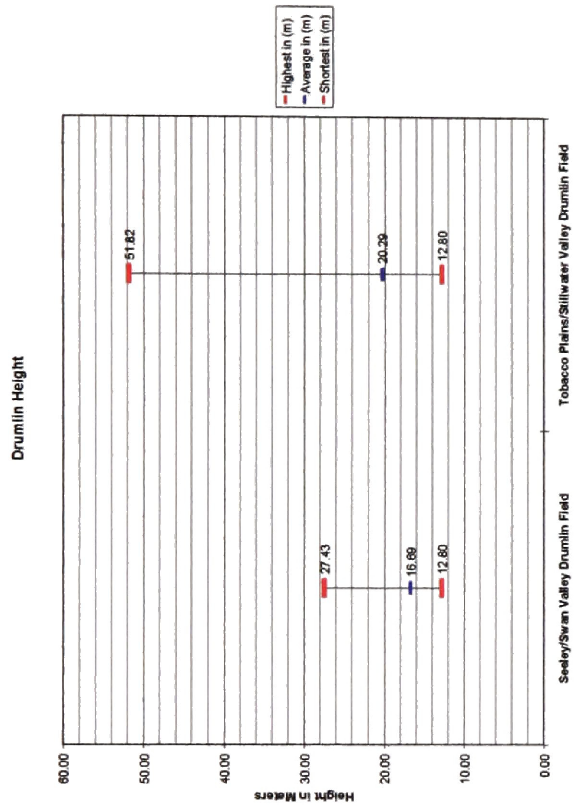



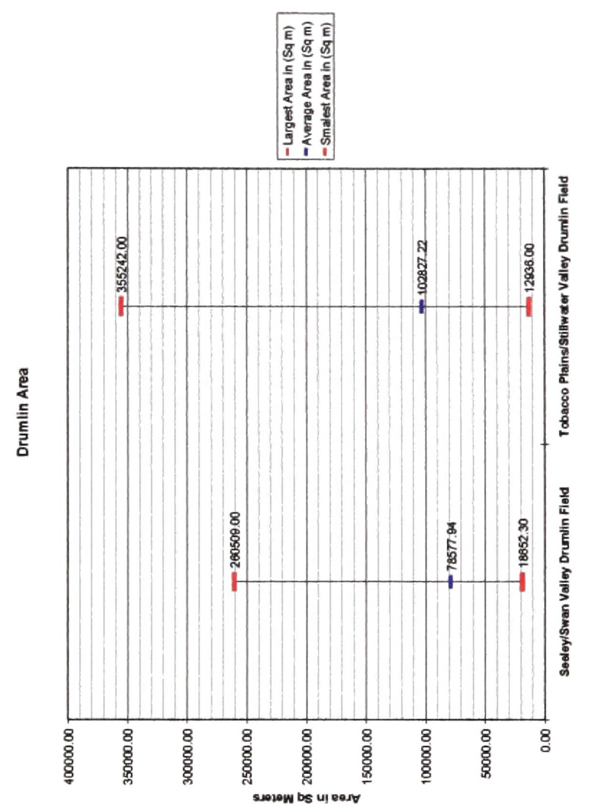
# APPENDIX J

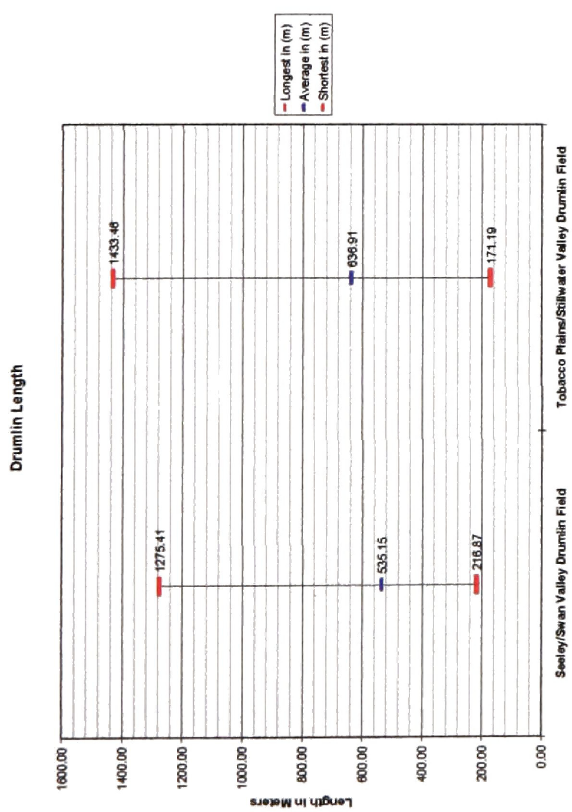
**Data Comparison Graphs**

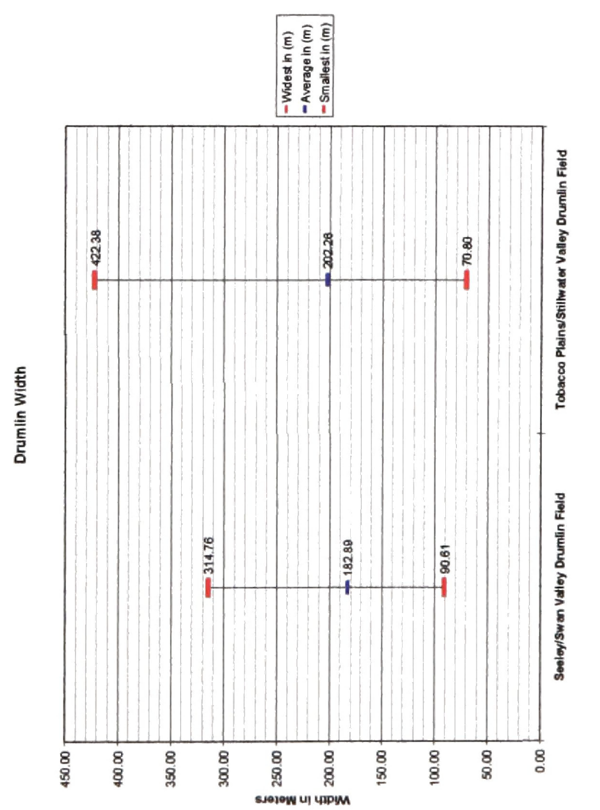
**Delineation Definition #1**

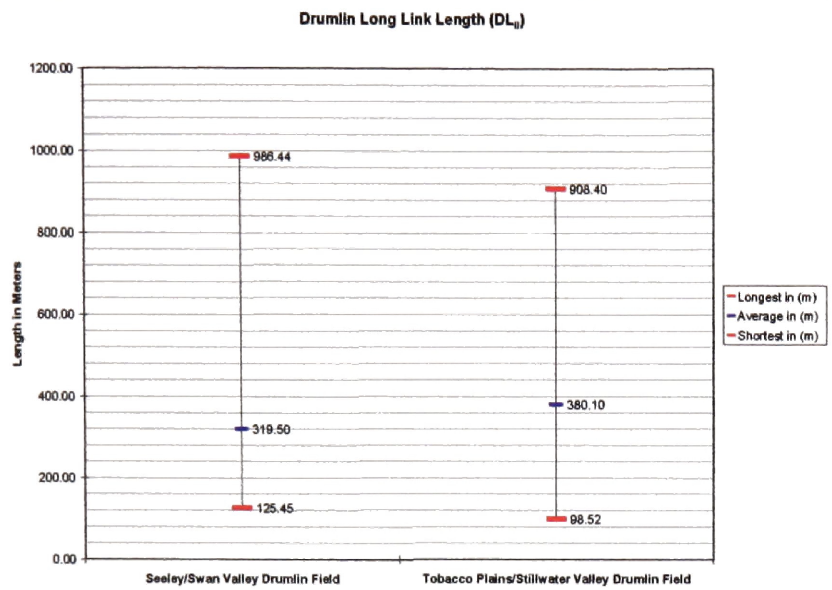
# Seeley/Swan & Tobacco Data Comparison Graphs – Delineation Definition #1

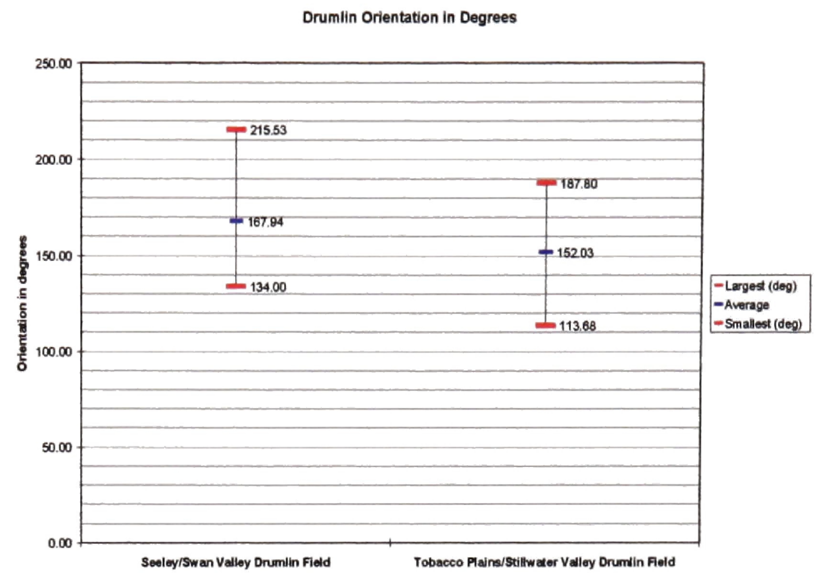


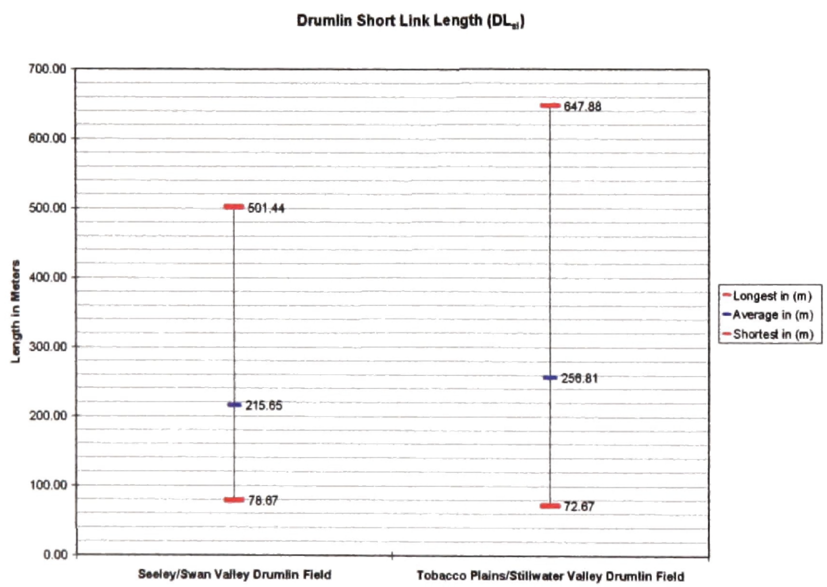



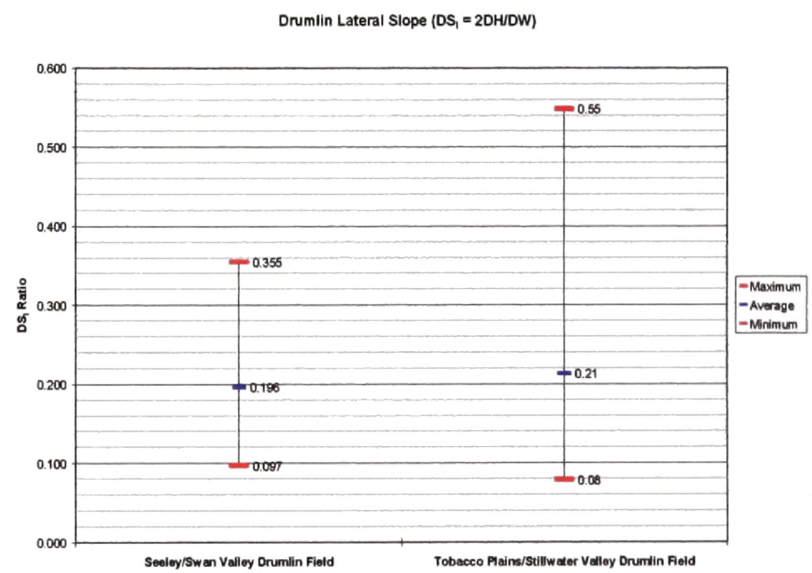



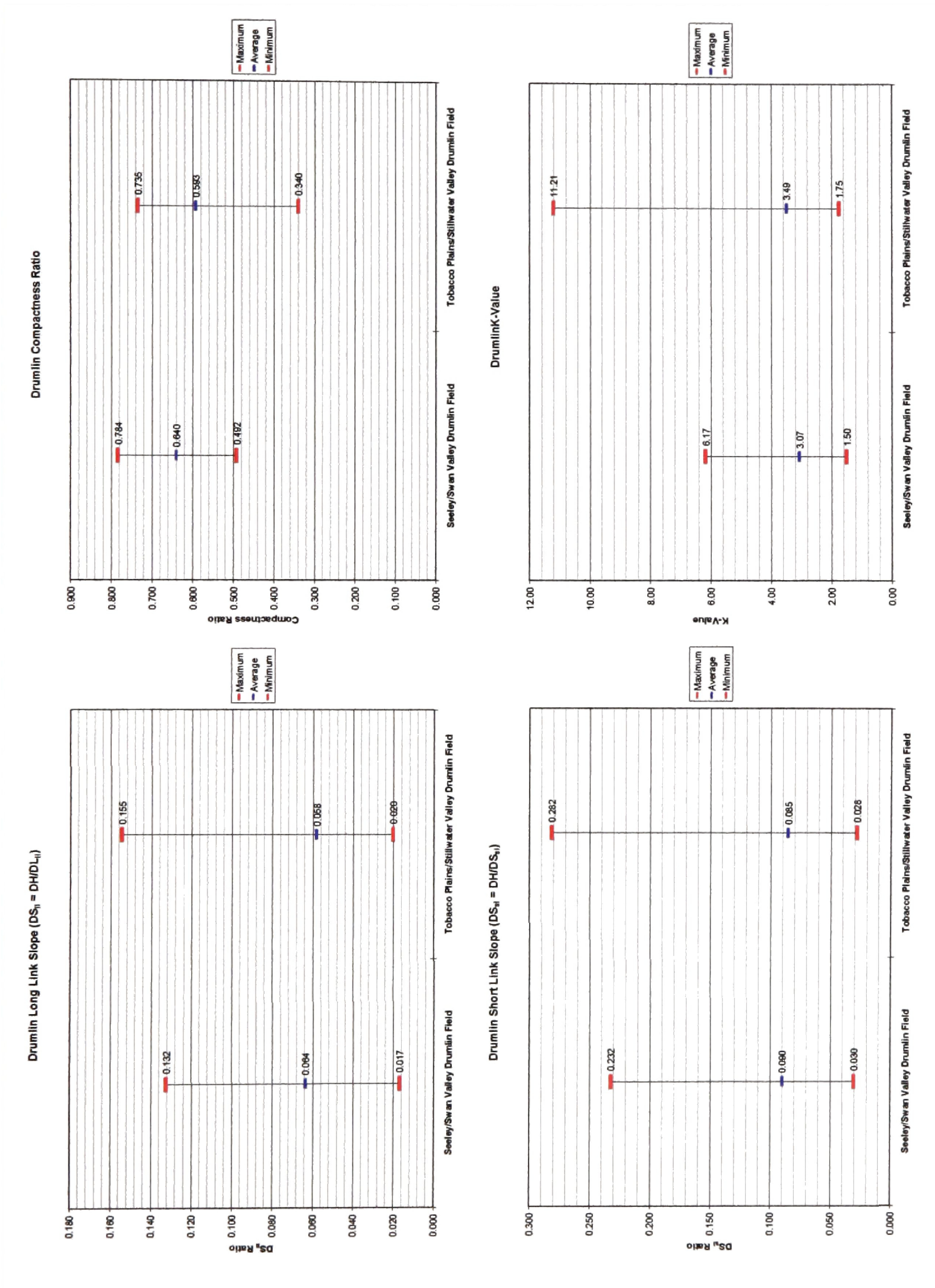

Drumlin Long Link Length ($DL_{ll}$)
Length in Meters
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
986.44
319.50
125.45
908.40
380.10
98.52
Longest in (m)
Average in (m)
Shortest in (m)
Seeley/Swan Valley Drumlin Field
Tobacco Plains/Stillwater Valley Drumlin Field


Drumlin Orientation in Degrees
Orientation in degrees
250.00
200.00
150.00
100.00
50.00
0.00
215.53
167.94
134.00
187.80
152.03
113.68
Largest (deg)
Average
Smallest (deg)
Seeley/Swan Valley Drumlin Field
Tobacco Plains/Stillwater Valley Drumlin Field

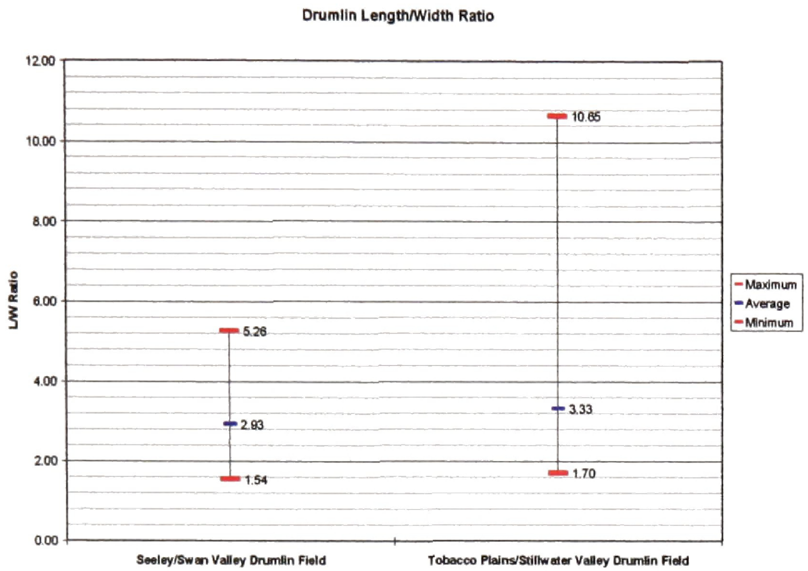

Drumlin Short Link Length ($DL_{sl}$)
Length in Meters
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
501.44
215.65
78.67
647.88
256.81
72.67
Longest in (m)
Average in (m)
Shortest in (m)
Seeley/Swan Valley Drumlin Field
Tobacco Plains/Stillwater Valley Drumlin Field

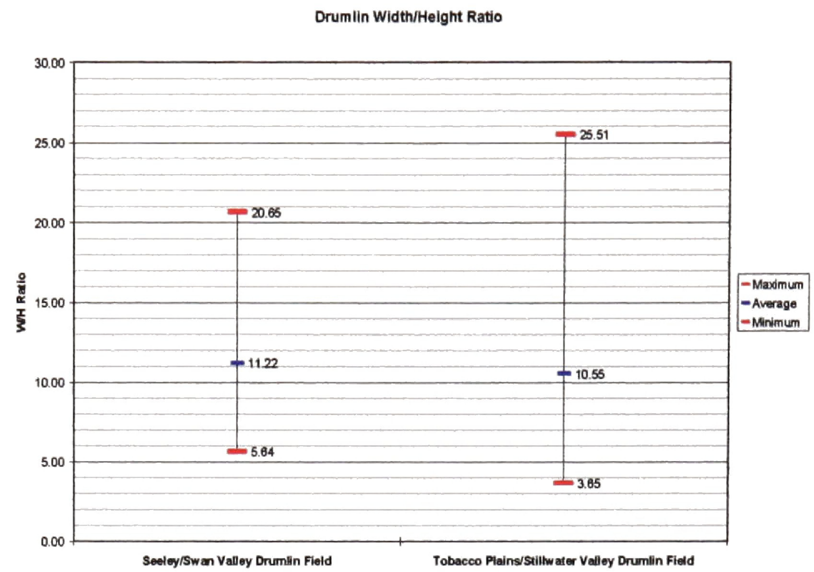

Drumlin Lateral Slope ($DS_l$ = 2DH/DW)
$DS_l$ Ratio
0.600
0.500
0.400
0.300
0.200
0.100
0.000
0.355
0.196
0.097
0.55
0.21
0.08
Maximum
Average
Minimum
Seeley/Swan Valley Drumlin Field
Tobacco Plains/Stillwater Valley Drumlin Field

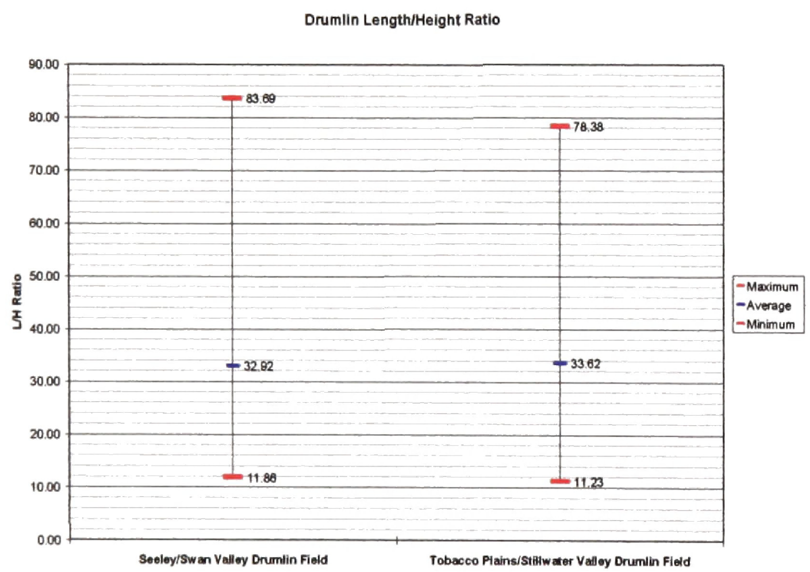
# Seeley/Swan & Tobacco Data Comparison Graphs – Delineation Definition #1

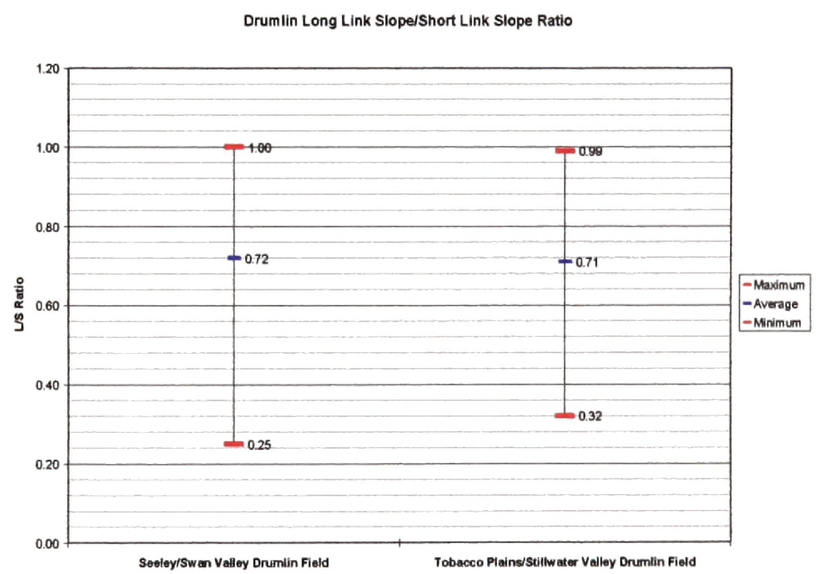


# Seeley/Swan & Tobacco Data Comparison Graphs – Delineation Definition #1

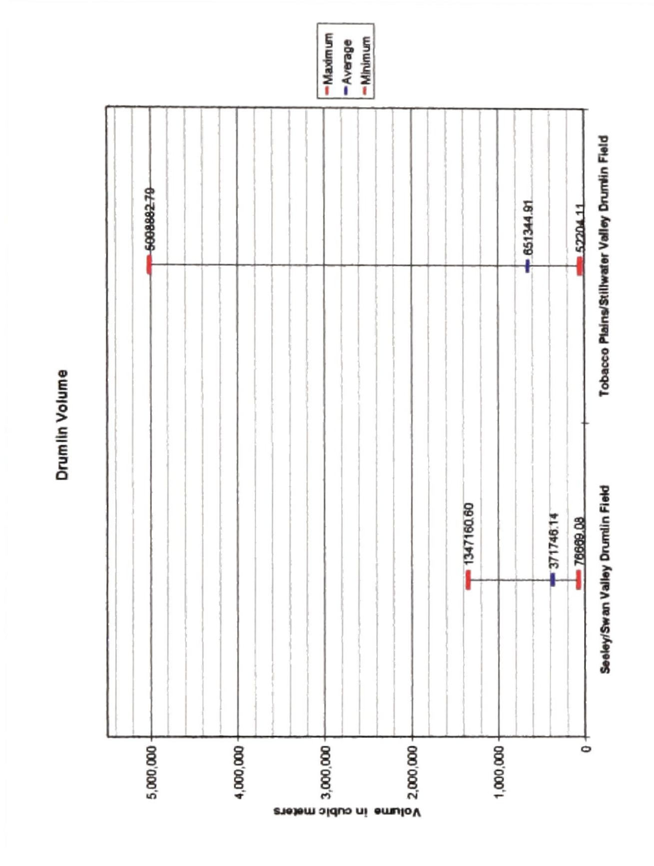


# Seeley/Swan & Tobacco Data Comparison Graphs – Delineation Definition #1

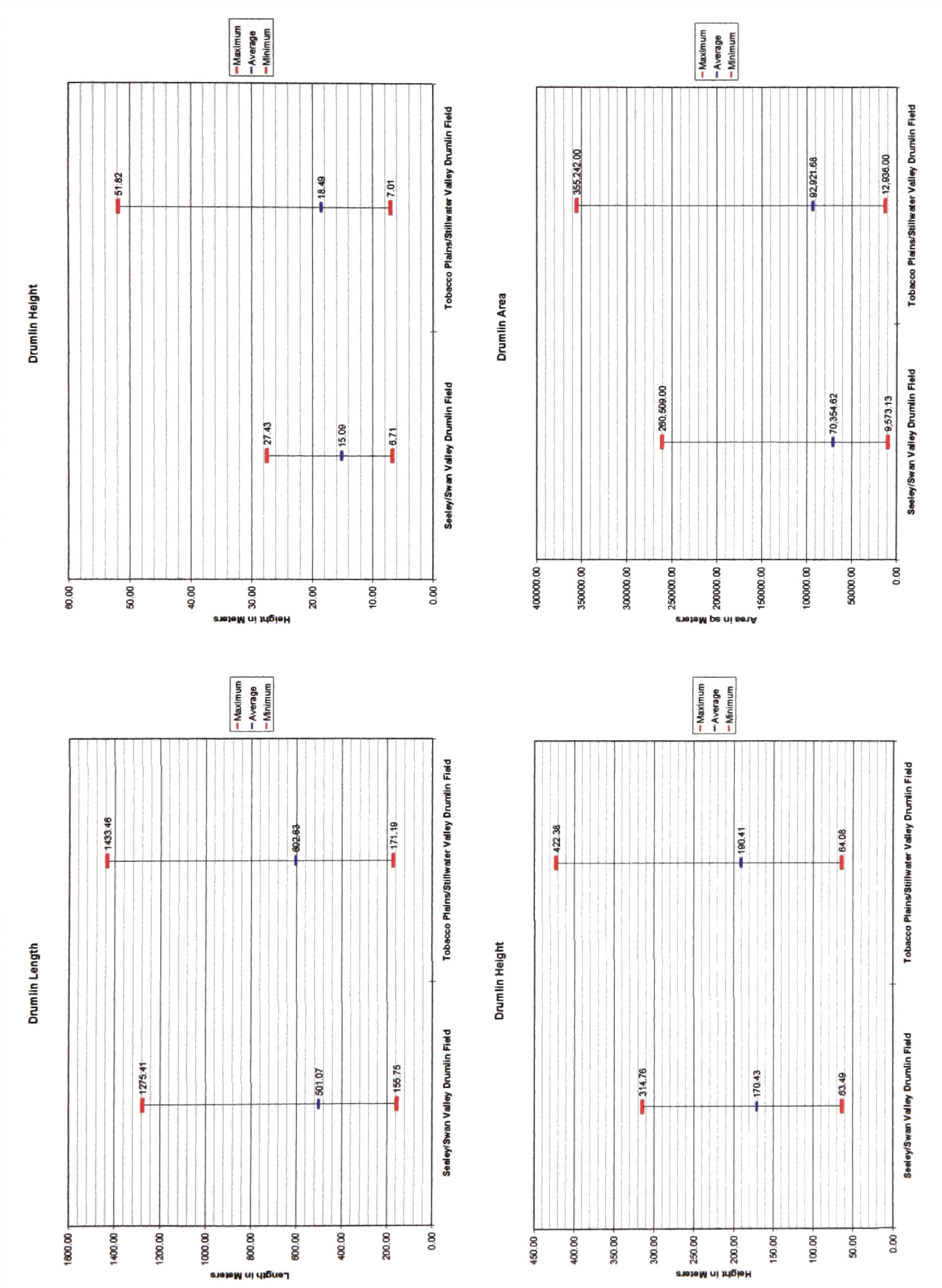


# APPENDIX K

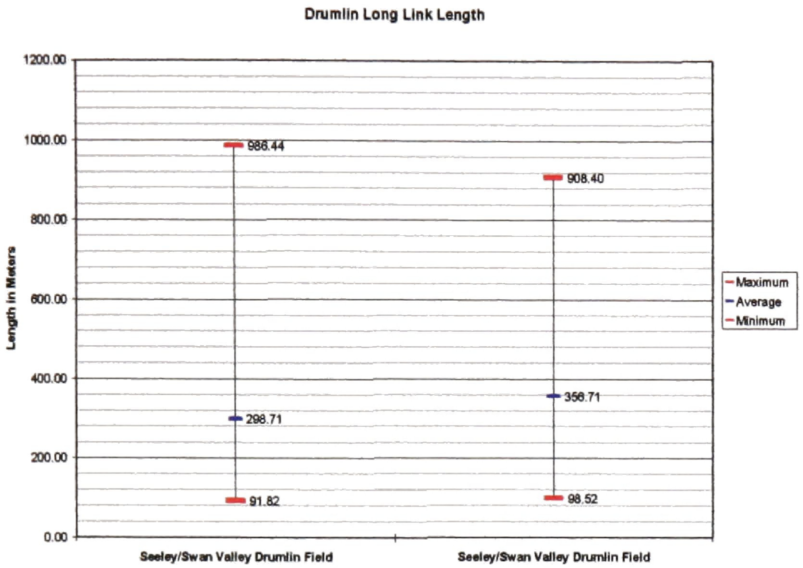
**Data Comparison Graphs**

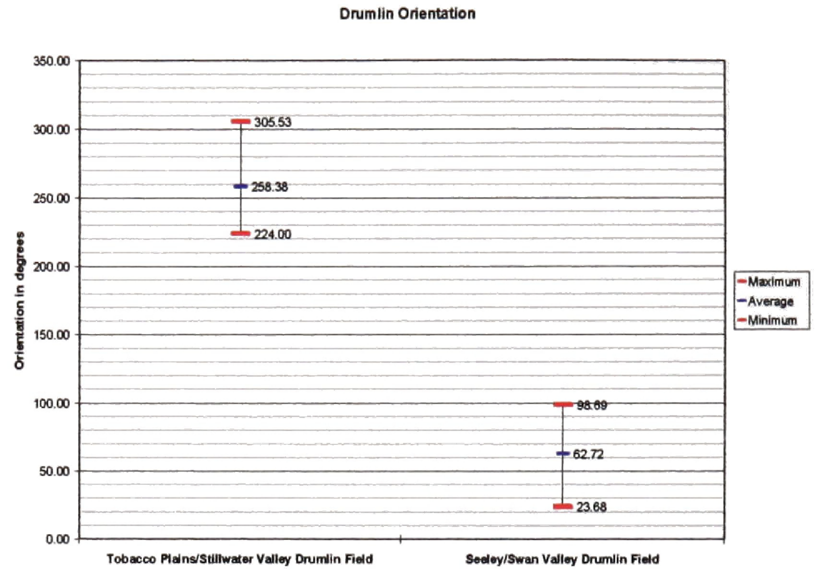
**Delineation Definition #2**

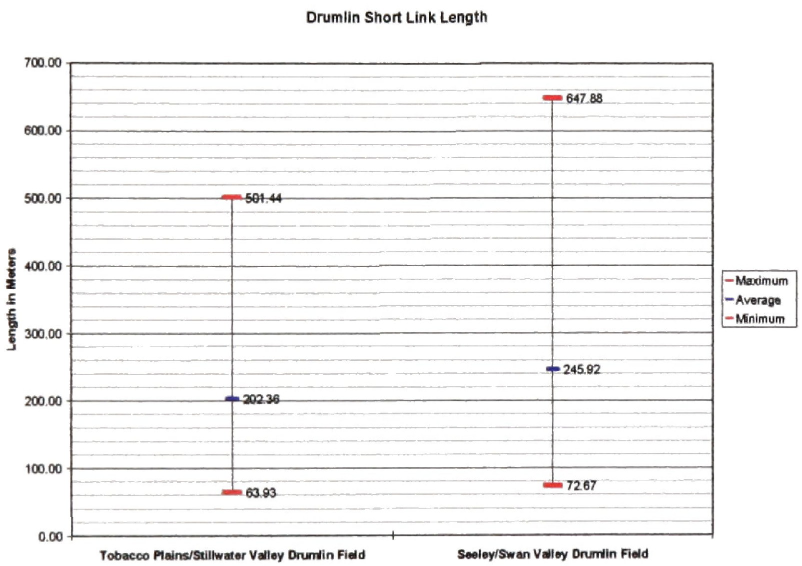
# Seeley/Swan & Tobacco Data Comparison Graphs – Delineation Definition #2

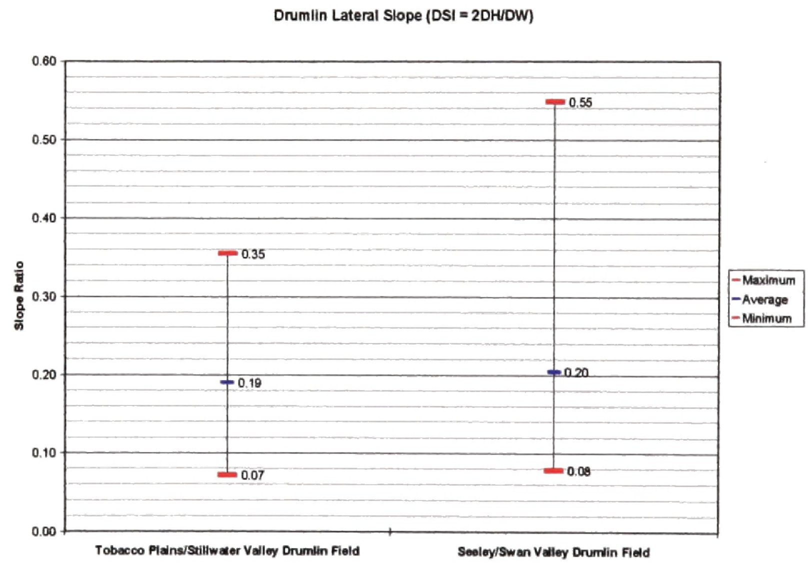


# Seeley/Swan & Tobacco Data Comparison Graphs – Delineation Definition #2

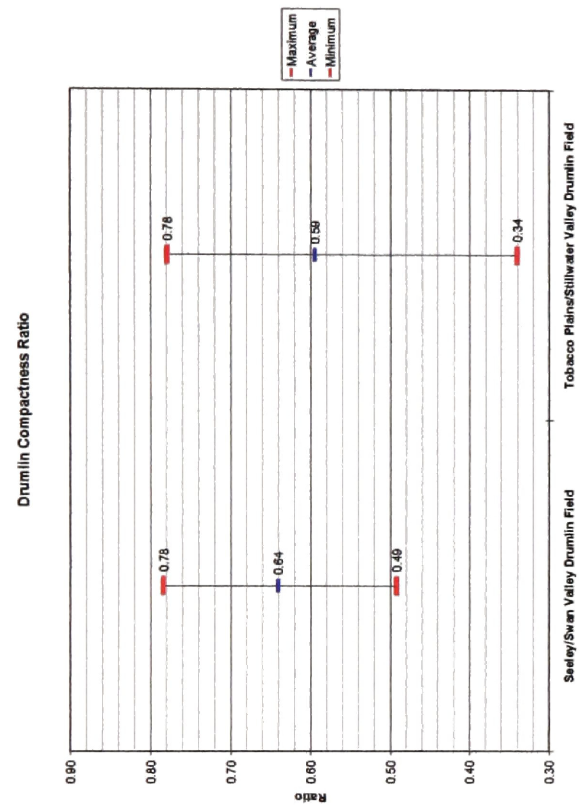


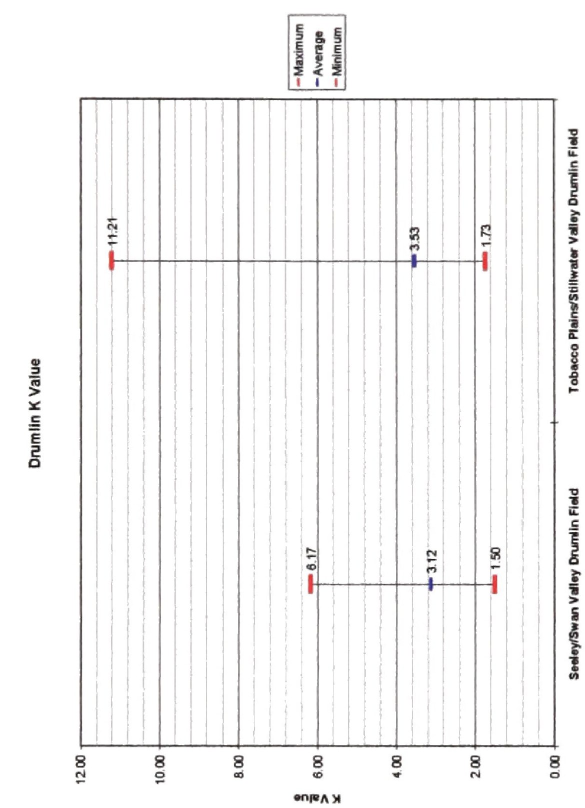



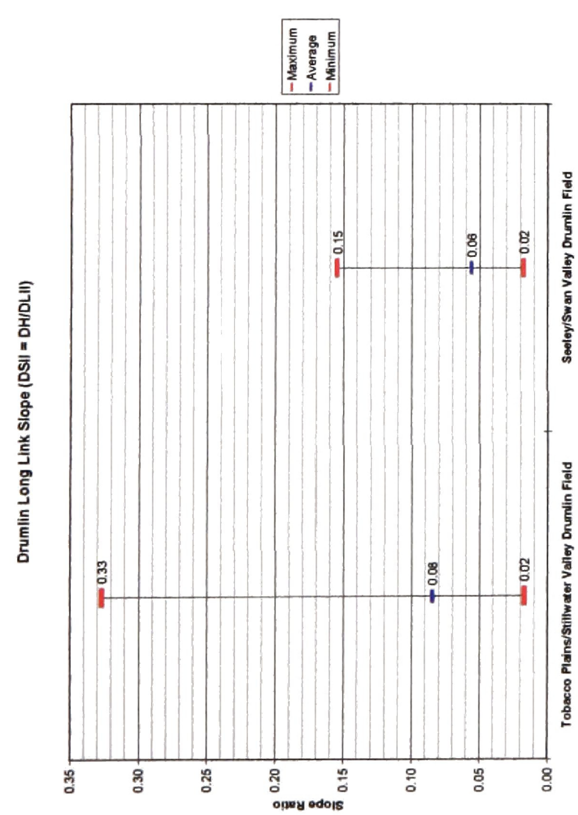



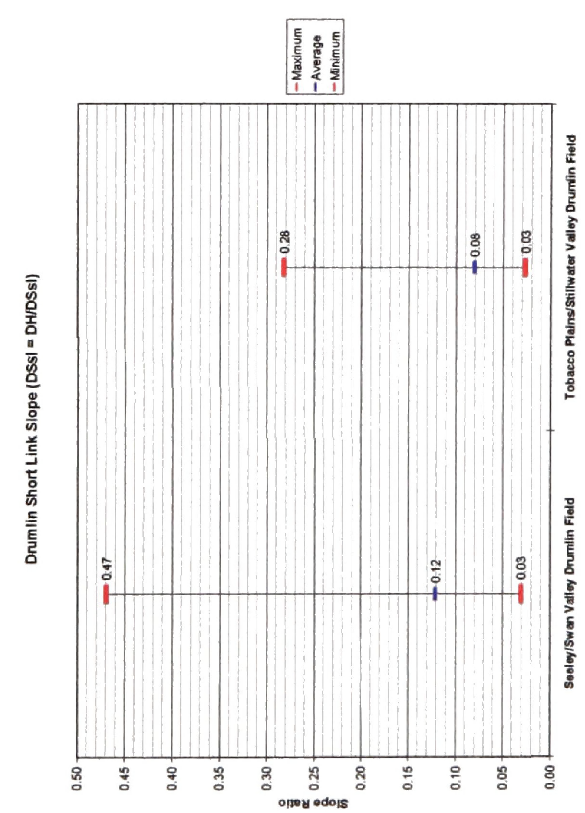



# Seeley/Swan & Tobacco Data Comparison Graphs – Delineation Definition #2

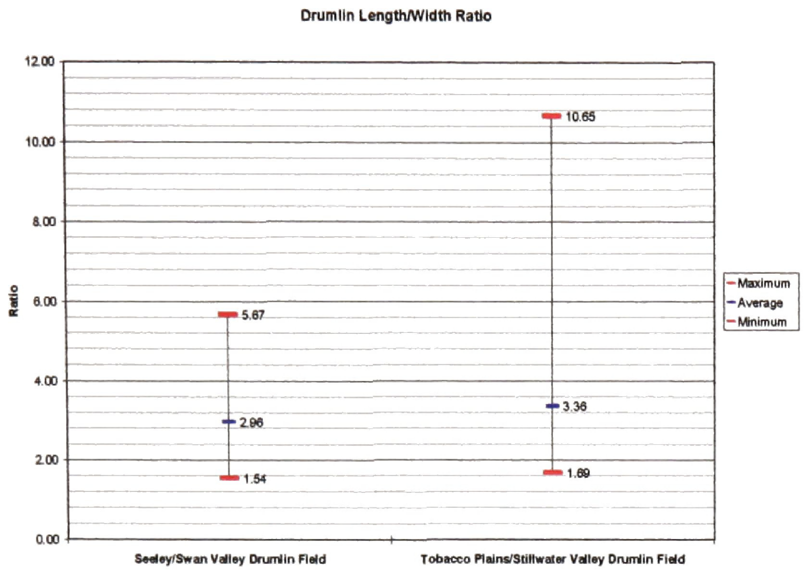


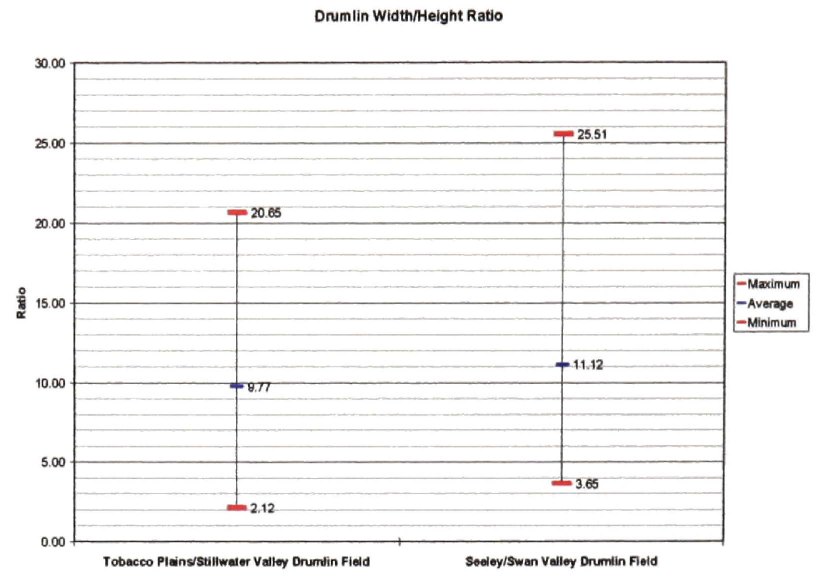



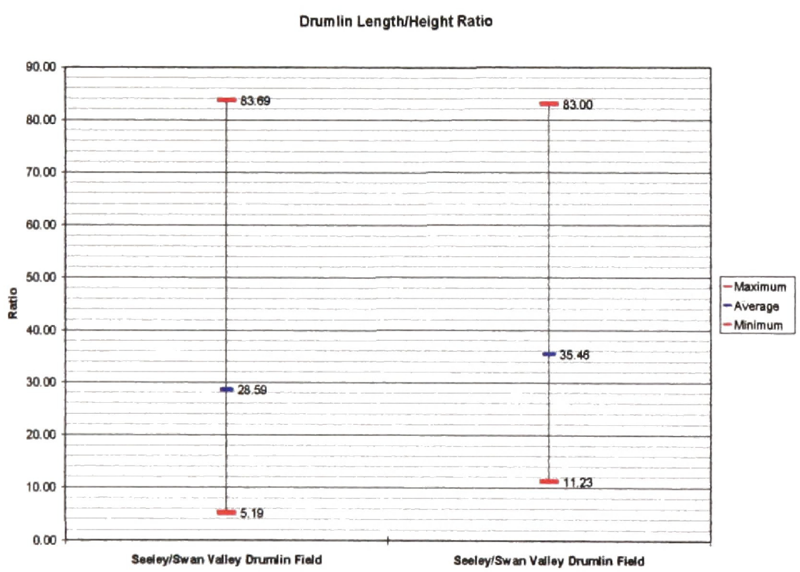



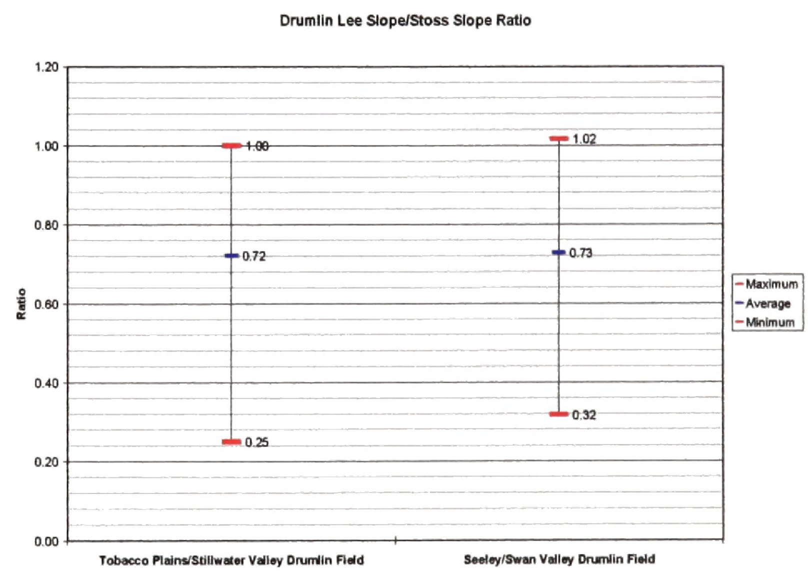



# Seeley/Swan & Tobacco Data Comparison Graphs – Delineation Definition #2

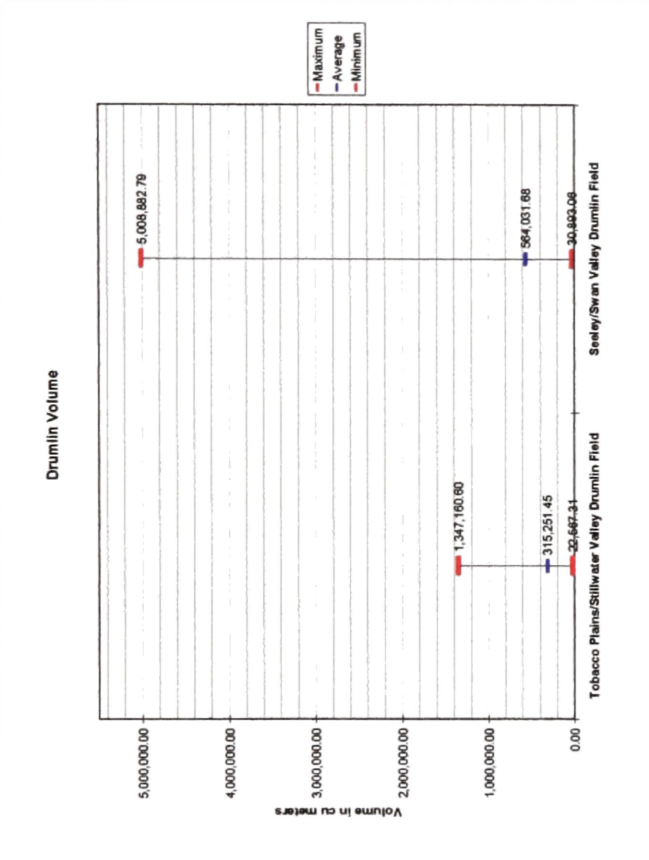


# Seeley/Swan & Tobacco Data Comparison Graphs – Delineation Definition #2



# APPENDIX L

**Correlation Matrices**

# Literature Drumlins - Correlation Matrices

(Mills, 1980)

**Northeast Mass.**

| | DL | DW | DH | L/W | L/H | W/H | $DS_{sl}$ | $DS_{ll}$ | L/S |
|---|---|---|---|---|---|---|---|---|---|
| DL | 1.00 | | | | | | | | |
| DW | 0.85 | 1.00 | | | | | | | |
| DH | 0.70 | 0.75 | 1.00 | | | | | | |
| L/W | 0.42 | -0.12 | 0.03 | 1.00 | | | | | |
| L/H | 0.42 | 0.15 | -0.36 | 0.53 | 1.00 | | | | |
| W/H | 0.14 | 0.28 | -0.44 | -0.19 | 0.73 | 1.00 | | | |
| $DS_{sl}$ | -0.19 | -0.05 | 0.39 | -0.27 | -0.74 | -0.64 | 1.00 | | |
| $DS_{ll}$ | -0.29 | -0.02 | 0.31 | -0.51 | -0.77 | -0.48 | 0.38 | 1.00 | |
| L/S | -0.10 | 0.03 | -0.05 | -0.24 | -0.07 | 0.11 | -0.52 | 0.60 | 1.00 |

All variables were logarithmically transformed (base 10) before analysis

**Central-West, NY**

| | DL | DW | DH | L/W | L/H | W/H | $DS_{sl}$ | $DS_{ll}$ | L/S |
|---|---|---|---|---|---|---|---|---|---|
| DL | 1.00 | | | | | | | | |
| DW | 0.34 | 1.00 | | | | | | | |
| DH | 0.34 | 0.63 | 1.00 | | | | | | |
| L/W | 0.41 | -0.72 | -0.35 | 1.00 | | | | | |
| L/H | 0.44 | -0.34 | -0.70 | 0.66 | 1.00 | | | | |
| W/H | 0.01 | 0.45 | -0.41 | -0.43 | 0.40 | 1.00 | | | |
| $DS_{sl}$ | -0.28 | 0.26 | 0.70 | -0.46 | -0.89 | -0.49 | 1.00 | | |
| $DS_{ll}$ | -0.50 | 0.34 | 0.57 | -0.71 | -0.93 | -0.25 | 0.68 | 1.00 | |
| L/S | -0.20 | 0.06 | -0.28 | -0.20 | 0.12 | 0.39 | -0.55 | 0.23 | 1.00 |

All variables were logarithmically transformed (base 10) before analysis

**Menominee, Mich.**

| | DL | DW | DH | L/W | L/H | W/H | $DS_{sl}$ | $DS_{ll}$ | L/S |
|---|---|---|---|---|---|---|---|---|---|
| DL | 1.00 | | | | | | | | |
| DW | 0.28 | 1.00 | | | | | | | |
| DH | 0.35 | 0.38 | 1.00 | | | | | | |
| L/W | 0.69 | -0.51 | 0.01 | 1.00 | | | | | |
| L/H | 0.62 | -0.03 | -0.52 | 0.56 | 1.00 | | | | |
| W/H | -0.05 | 0.51 | -0.60 | -0.45 | 0.46 | 1.00 | | | |
| $DS_{sl}$ | -0.33 | 0.03 | 0.59 | -0.32 | -0.79 | -0.52 | 1.00 | | |
| $DS_{ll}$ | -0.60 | 0.03 | 0.41 | -0.57 | -0.88 | -0.35 | 0.57 | 1.00 | |
| L/S | -0.25 | -0.01 | -0.24 | -0.23 | -0.03 | 0.21 | -0.53 | 0.40 | 1.00 |

All variables were logarithmically transformed (base 10) before analysis

## Literature Drumlins - Correlation Matrices

**Green Bay, Wis.**

| | DL | DW | DH | L/W | L/H | W/H | $DS_{sl}$ | $DS_{ll}$ | L/S |
|---|---|---|---|---|---|---|---|---|---|
| DL | 1.00 | | | | | | | | |
| DW | 0.46 | 1.00 | | | | | | | |
| DH | 0.26 | 0.45 | 1.00 | | | | | | |
| L/W | 0.78 | -0.21 | -0.04 | 1.00 | | | | | |
| L/H | 0.73 | 0.12 | -0.47 | 0.73 | 1.00 | | | | |
| W/H | 0.14 | 0.40 | -0.64 | -0.13 | 0.59 | 1.00 | | | |
| $DS_{sl}$ | -0.49 | -0.04 | 0.56 | -0.52 | -0.85 | -0.60 | 1.00 | | |
| $DS_{ll}$ | -0.75 | -0.15 | 0.35 | -0.74 | -0.94 | -0.49 | 0.64 | 1.00 | |
| L/S | -0.29 | -0.12 | -0.24 | -0.24 | -0.09 | 0.14 | -0.44 | 0.42 | 1.00 |

All variables were logarithmically transformed (base 10) before analysis

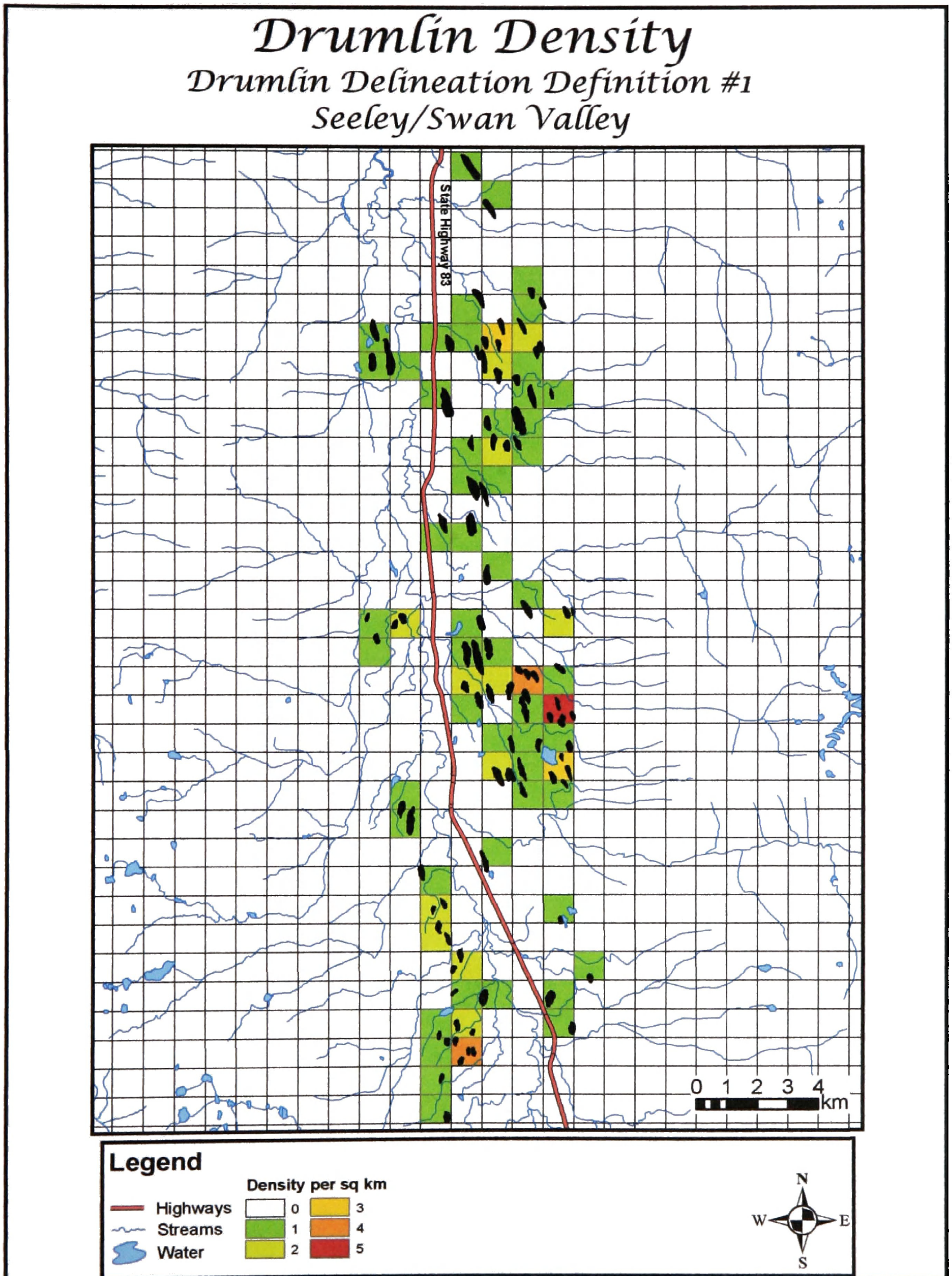
**Wadena, Minn.**

| | DL | DW | DH | L/W | L/H | W/H | $DS_{sl}$ | $DS_{ll}$ | L/S |
|---|---|---|---|---|---|---|---|---|---|
| DL | 1.00 | | | | | | | | |
| DW | 0.45 | 1.00 | | | | | | | |
| DH | 0.06 | 0.25 | 1.00 | | | | | | |
| L/W | 0.75 | -0.26 | -0.25 | 1.00 | | | | | |
| L/H | 0.82 | 0.21 | -0.62 | 0.73 | 1.00 | | | | |
| W/H | 0.40 | 0.58 | -0.65 | 0.00 | 0.68 | 1.00 | | | |
| $DS_{sl}$ | -0.77 | -0.23 | 0.57 | -0.66 | -0.94 | -0.66 | 1.00 | | |
| $DS_{ll}$ | -0.72 | -0.14 | 0.62 | -0.67 | -0.92 | -0.63 | 0.78 | 1.00 | |
| L/S | 0.10 | 0.14 | 0.05 | 0.01 | 0.05 | 0.07 | -0.36 | 0.30 | 1.00 |

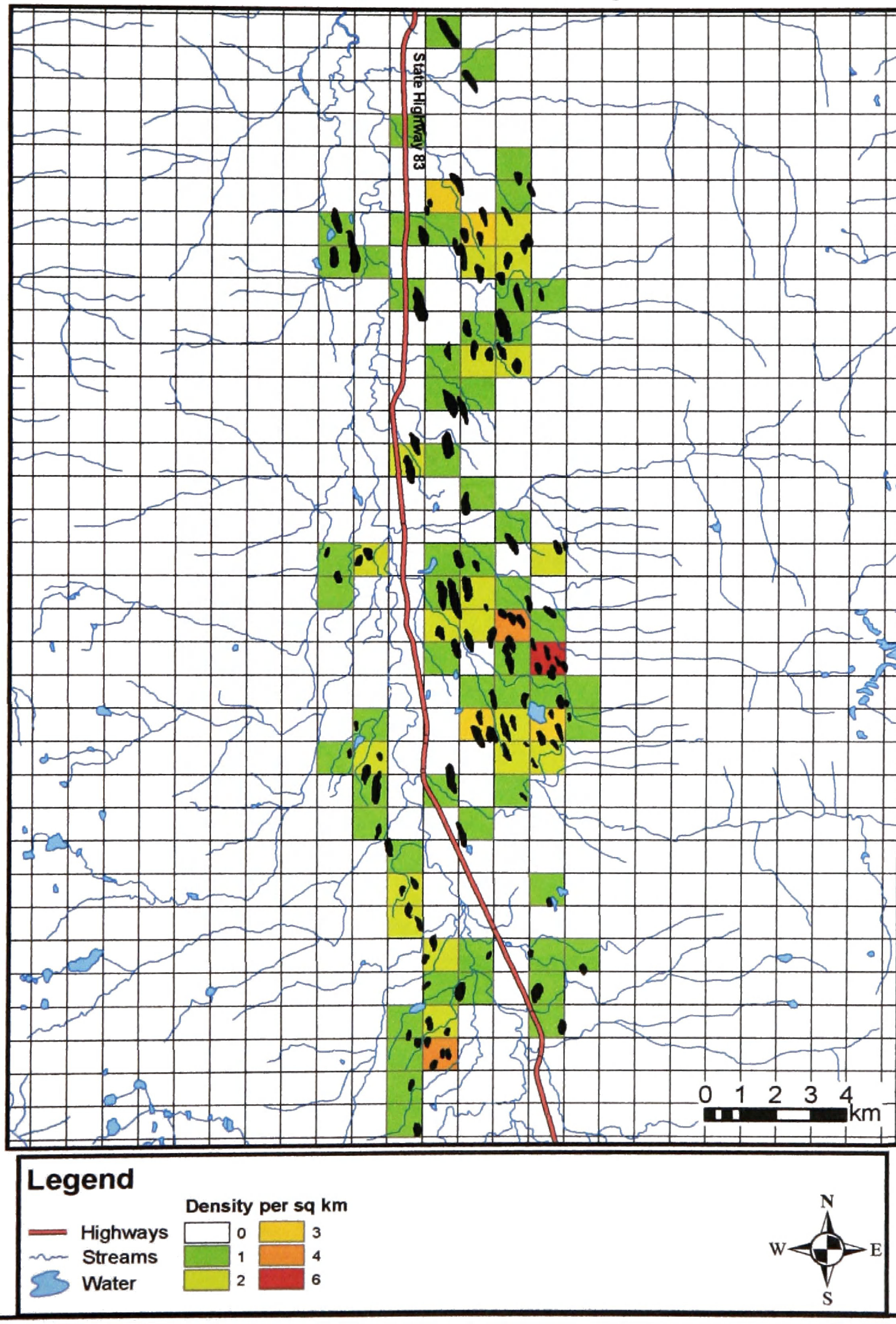
All variables were logarithmically transformed (base 10) before analysis

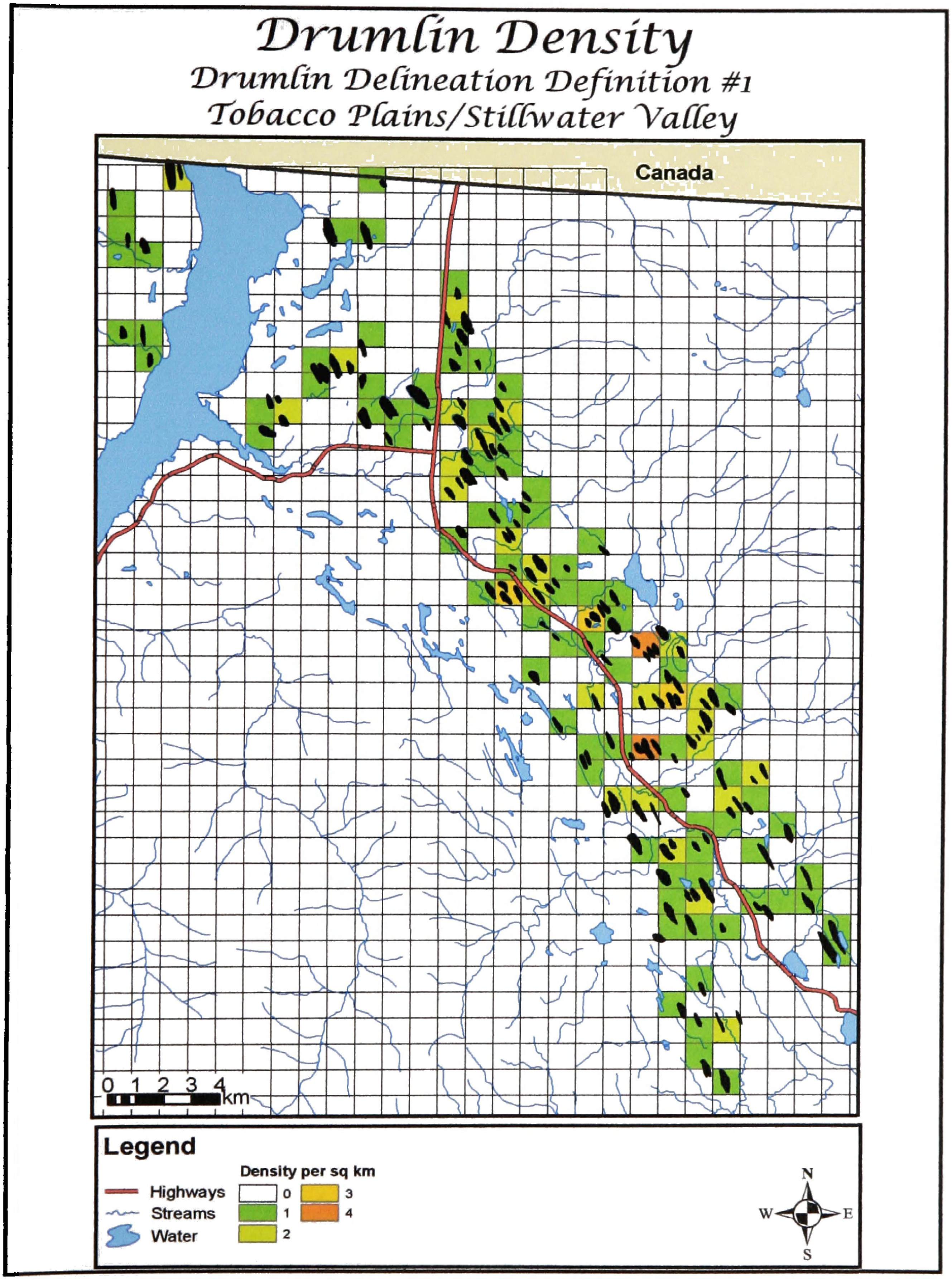
# APPENDIX M

**Drumlin Density Maps**


Drumlin Density
Drumlin Delineation Definition #1
Seeley/Swan Valley
State Highway 83
0 1 2 3 4
km
Legend
Density per sq km
Highways
Streams
Water
0
1
2
3
4
5
N
S
W
E

# Drumlin Density
## Drumlin Delineation Definition #2
## Seeley/Swan Valley





Drumlin Density
Drumlin Delineation Definition #1
Tobacco Plains/Stillwater Valley
Canada
0 1 2 3 4
km
Legend
Highways
Streams
Water
Density per sq km
0
1
2
3
4
N
S
E
W

# Drumlin Density

## Drumlin Delineation Definition #2

## Tobacco Plains/Stillwater Valley