

***Distribution of Seasonal Ponded Areas on Geomorphic Surfaces of Selected
East-West Transects of the Willamette Valley.***

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Summary of Major Findings

1. The threshold for the first occurrence of extensive ponding requires about 5 inches of cumulative rainfall at the onset of the rainy season.
2. Extensive ponding first develops on the slowly permeable, somewhat poorly drained and poorly drained soils on the Calapooyia, Winkle, and Ingram surfaces. Ponding on the better drained soils occurs later in the rainy season.
3. Fully 50% of the locations at which ponding was observed are on the Calapooyia geomorphic surface. One-third are on the Ingram Surface. Only 2% of all locations at which ponding was observed are on the Senecal surface.
4. The density of ponding, defined as the number of ponds per observation location, is much higher on the Calapooyia surface than on other surfaces.
5. There is some evidence that ponds on the Calapooyia surface retain water for longer periods of time than ponds on other geomorphic surfaces. Conversely, many ponds on the Calapooyia surface contain water for only short periods of time.
6. Pond size is relatively evenly distributed among small, medium, and large ponds on all geomorphic surfaces. There is no evidence for the occurrence of a few very large ponds and a large number of very small ponds.
7. As late spring rainfall decreases, ponds begin to dry up at about the same time and at the same rate on all geomorphic surfaces. The rate of drying is slower for ponded sites in the southern Willamette valley than for those in the northern Willamette valley.
8. Tillage practices in farm fields affects ponding either by reshaping naturally occurring ponded areas or by creating depressions that subsequently retain water in the rainy season.
9. Naturally occurring wetland plants are good indicators of sites that later become ponded, but they are not infallible. Some sites characterized by wetland vegetation did not contain ponded water at the times of observation.
10. Yellowing of cultivated crops provided a good indicator of ponded sites.

Distribution of Seasonal Pondered Areas on Geomorphic Surfaces of Selected East-West Transects of the Willamette Valley.

Soils and Geomorphic Surfaces

Seasonal ponding implies that soils will have water standing on the surface for some period of time in response to late fall, winter, and early spring precipitation. The extent of ponding was characterized by observing the frequency of ponding and the general size of ponds along three transects across the Willamette valley. Because there is a good relationship between soils and the landforms on which they occur, the observations were stratified according to geomorphic surfaces.

Major geomorphic surfaces of the Willamette Valley include the Ingram, Winkle, Calapooyia, and Senecal. Associations between soils and surfaces are summarized in Table 1.

The Ingram represents the floodplain of the Willamette River and its tributaries. Well drained Newberg and Chehalis soils dominate this surface, but there is some natural swell and swale topography, and poorly drained Waldo, Wapato, and Bashaw soils do occur in some of the swales and on the floodplains of smaller tributaries. If ponding occurs, we would expect to find it in the swales and associated with the poorly drained soils.

The Winkle surface represents a stream terrace of the Willamette River system. Major soils include the well drained Malabon and Salem soils, the moderately well drained Coburg soils, the somewhat poorly drained Clackamas soils, and the poorly drained Awbrig, Conser, and Cove soils. Swell and swale topography is less pronounced than on the Ingram surface, and we would expect ponding to be associated primarily with the poorly drained soils.

The Calapooyia surface represents the broad, flat surface that constitutes much of the main valley floor. This surface was created by deposition associated with the Missoula floods; it has very little relief and a very poorly developed drainage system. The soils are characterized by a very slowly permeable clay layer at shallow depth that perches water throughout the winter rainy season. Consequently the majority of the soils are the poorly drained Dayton and Concord soils and the somewhat poorly drained Amity and Holcomb soils. Ponding is known to occur on this surface, and we would expect to observe ponding in many places.

The Senecal surface is also on the main valley floor, but it is more dissected and the soils do not have a restrictive clay layer. It is characterized by the well drained Willamette soil and the moderately well drained Woodburn soil. We would expect ponding to occur very infrequently on these soils.

Table 1. Dominant soils on major geomorphic surfaces of the Willamette valley.

Soil Series	Drainage Class	Parent Material	Topography	Geomorphic Surface
Camas (Ca)	ED	recent sandy, gravelly alluvium	bottomlands, floodplains	Horseshoe
Chehalis (Ch)	WD	mixed alluvium	undulating floodplains	Ingram
Cloquato (Cl)	WD	recent alluvium	undulating floodplains on bottomlands	Ingram
McAlpin (Ml)	MWD	stratified alluvium	fans and floodplains	Ingram
McBee (Mb)	MWD	weathered sedimentary alluvium	alluvial bottoms, undulating floodplains	Ingram
Newburg (Nw)	SWED	recent alluvium	floodplains, alluvial bottoms	Ingram
Waldo (Wa)	PD	silty and clayey alluvium	depressional areas on high floodplains / low stream terraces	Ingram
Wapato (Wp)	PD	fine textured recent alluvium	old abandoned river channels and depressions on floodplains	Ingram
Bashaw (Ba)	PD or VPD	clayey alluvium	floodplain terraces, sloping fans	Luckimute, Ingram

Soil Series	Drainage Class	Parent Material	Topography	Geomorphic Surface
Awbrig (Aw)	PD	silty and clayey alluvium	concave areas on low alluvial stream terraces	Winkle
Clackamas (Ck)	SWPD	gravelly alluvium	concave areas on low alluvial stream terraces	Winkle
Coburg (Co)	MWD	silty and clayey alluvium	broad, low stream terraces	Winkle
Conser (Cn)	PD	silty and clayey alluvium	concave low alluvial stream terraces	Winkle
Courtney (Cr)	PD	alluvium of differing ages	shallow depressions and drainageways of gravelly alluvial terraces	Winkle
Cove (Cv)	PD	recent alluvium	bottomlands	Winkle
Labish (Lb)	PD	mixed organic and mineral	former lake bottoms	Winkle
Malabon (Ma)	WD	silty and clayey alluvium	broad low stream terraces	Winkle
Salem (Sa)	WD	gravelly alluvium	convex low alluvial stream terraces	Winkle

Soil Series	Drainage Class	Parent Material	Topography	Geomorphic Surface
Concord (Cc)	PD	stratified silty and clayey alluvium	slight concave terraces and drainageways	Calapooyia
Amity (Am)	SWPD	silty alluvium, lacustrine silt	slightly concave areas on broad terraces	Calapooyia
Dayton (Da)	PD	clayey and silty alluvium	broad terraces and smooth or concave stream terraces or drainageways	Calapooyia
Holcomb (Ho)	SWPD	silty and clayey alluvium	nearly level, broad terraces	Calapooyia
Willamette (Wi)	WD	silty alluvium	broad terraces above floodplain	Senecal
Woodburn (Wo)	MWD	silty alluvium	broad terraces	Senecal

Transect Identification

East-west transects generally run perpendicular to the geomorphic surfaces of the Willamette valley. Three such transects were established along roadways that cross the Willamette valley (Figure 1). Geomorphic surfaces along each transect were mapped by using the corresponding soil information from the soil surveys of Benton, Linn, Polk, Marion, and Yamhill counties.

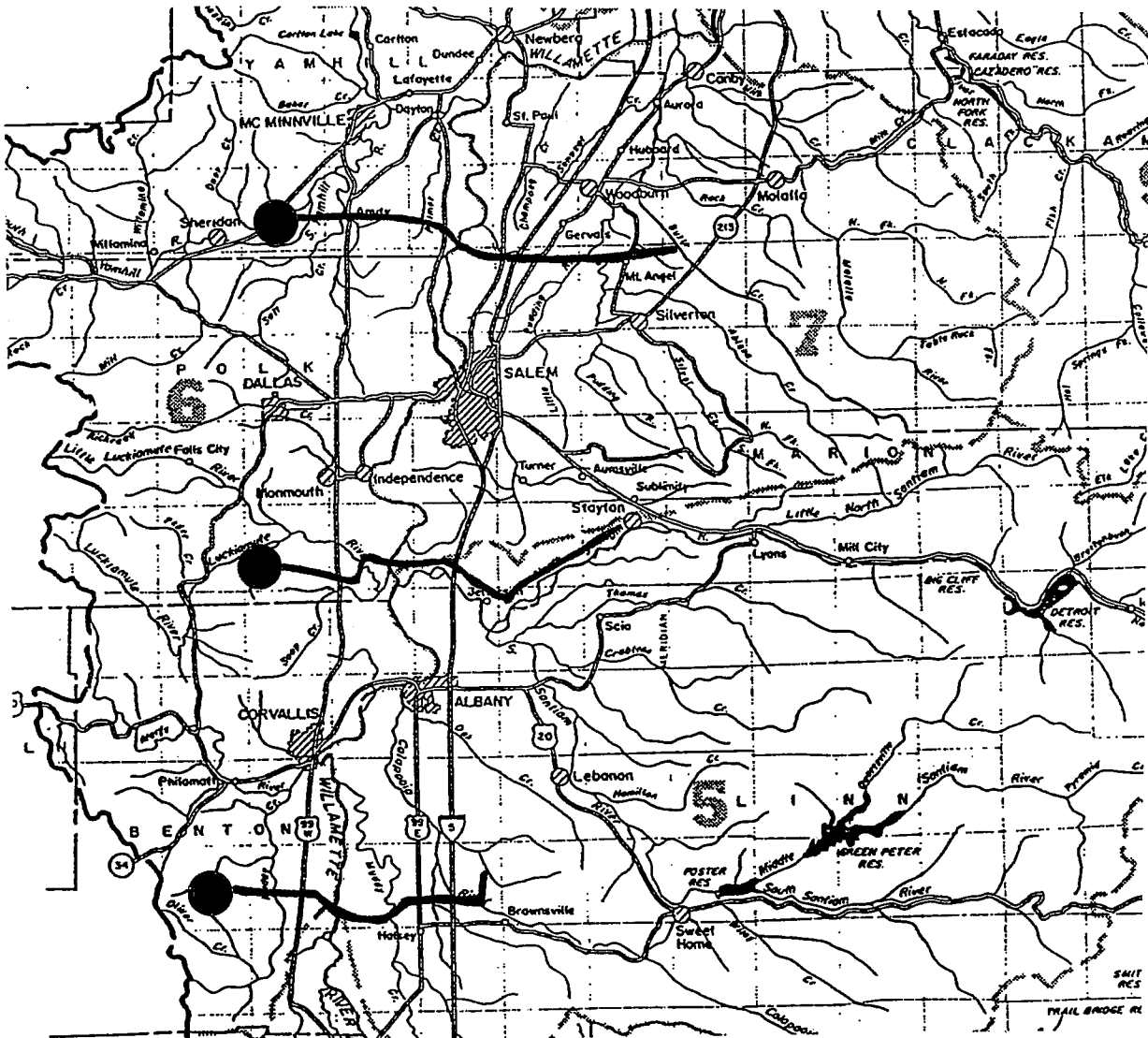


Figure 1. Locations of observation transects across the Willamette valley.
 Note : red dots identify transect location on Figure 1. (B-L is Benton-Linn transect, P-M is Polk-Marion transect, Y-M is Yamhill-Marion transect.)

The transect identified as **Benton-Linn** begins near Inavale School and follows Greenberry Road and Smith Loop to Porter Lake in Benton County. Continuing east into Linn County, the transect follows Lone Pine Road near Peoria to Potter and Linn-West Road and ends at the junction of Manning and Harrison Roads. Most of this transect is on the Calapooyia geomorphic surface.

The **Polk-Marion** transect begins near Airlie, heads toward Suver, then goes northerly to Buena Vista. Continuing in Marion County the transect goes to Talbot, Jefferson, Marion, and ends near Stayton. Much of this transect is on the Ingram and Winkle geomorphic surfaces.

The **Yamhill-Marion** transect runs from Bellevue in Yamhill County through Amity, over the Eola hills to Hopewell, and ends in Wheatland. Continuing in Marion County the transect runs from the Wheatland Ferry landing to Waconda, Parkersville School, north to Mt. Angel-Dominic Road, then east near Butte Creek and the Clackamas County line. Most of this transect is on the Calapooyia and Senecal geomorphic surfaces.

Data Collection

Observational data were collected at a total of 233 locations over all three transects. A location is defined as a 0.1 mile segment on a transect. At each location observations were made of the estimated number of ponds visible and the relative size of the ponds, and some photographs were taken. Because the data on number and size of ponds are imprecise, most of the data summaries that follow are based on the percentages of the locations that showed certain features.

All location data were recorded in a mileage log compiled for each transect (Table 2). The number of ponds observed at each location (Quantity in table 2) was recorded in three classes: 1 pond (P), 2-3 ponds (F), and ≥ 4 ponds (E). The areal extent of ponding (Size in Table 2) was recorded in four classes of estimated maximum dimension: < 10 meters, 10-20 meters, 20-30 meters, and > 30 meters. The log also documents locations of surface photographs (P in Table 2), compass direction from roadway to ponds (Loc in Table 2), and the soil and geomorphic surface on which a pond occurred (Soil in Table 2).

Surface photos were first taken in late October, after most harvest operations along the transects appeared to be completed. This allowed for maximum visibility of soil color patterns and microrelief and land contours. Soil colors are important because darker colors were taken as indicators of predicted sites of future ponding. Microrelief, particularly that of shallow depressions, is another indicator of predicted ponding as it is known to affect surface hydrology and may also control the drainage of ponds.

Surface photos were again taken in January and in early March to document the occurrence of ponding along each transect. These photos also show how vegetation patterns develop during the rainy season and may provide important clues for predicting where ponds will develop.

Aerial photographs were taken with a 35mm camera from an altitude of approximately 1400 feet on April 24 and May 24. By this time the growth of surface vegetation made it very difficult to observe ponded sites from roadsides. Aerial photographs were used to document the drying part of the ponding cycle and to provide further information on the color patterns associated with vegetative response to the presence of ponds.

Threshold for Ponding

Extensive ponding - defined as more than 4 ponds in a 0.1 mile segment of a transect - was first observed on December 8, 1993 along the Benton-Linn transect and along the Polk segment of the Polk-Marion transect. By this time the cumulative total amount of precipitation that had been received since the onset of the rainy season in late September was 4.7 inches (Figure 2). Thus, although these data are very preliminary, they do suggest that it takes approximately 5 inches of rainfall to satisfy the soil moisture storage capacity, after which additional rainfall may instigate surface ponding. More observations over several rainy seasons would be necessary to verify this preliminary observation.

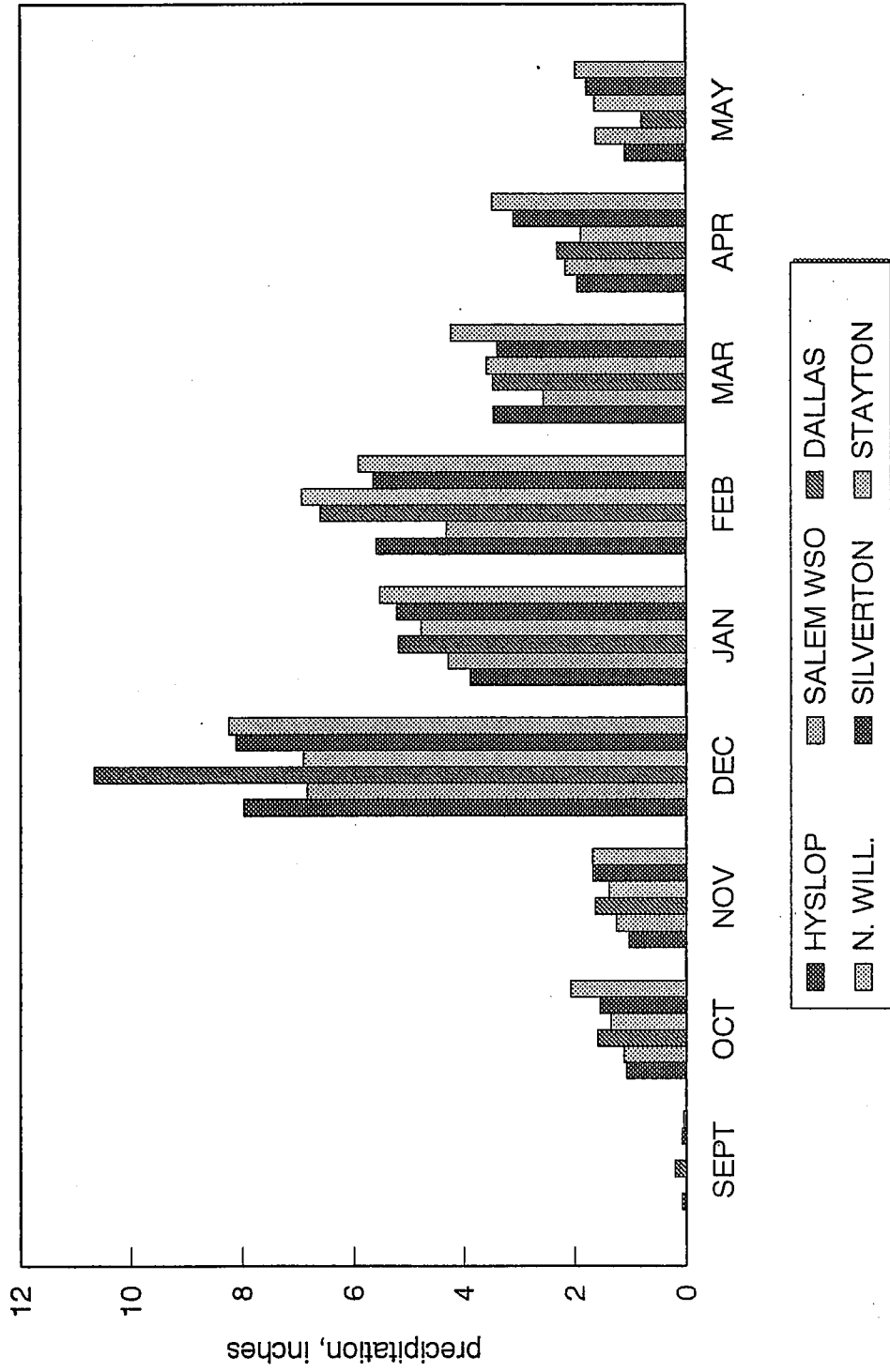


Figure 2. Precipitation data for the 1993-1994 rainy season as recorded at 6 stations in the Willamette valley.

Most of the first observable ponds along the Polk, Benton, and Linn segments of the transects were on the Calapooyia geomorphic surface. Because many of the soils on this surface have a restrictive clay layer at shallow depth, less total rainfall is required to saturate that soil above the clay and initiate surface ponding. When initial ponding was first observed at a later date along the Yamhill-Marion County transect, it, too, was concentrated on the Calapooyia surface. Initial ponding on the Marion segment of the Polk-Marion transect was concentrated on the Ingram surface.

Some of the first observable ponds along all transects occurred on the Ingram surface. These were sites that were either markedly depressional or were characterized by poorly drained and slowly permeable soils. Later in the rainy season, particularly on March 1, 1994, there were a large number of Ingram ponds that were filled by flooding from streams and rivers, which at that time were at bankfull stage or slightly higher.

Extensive ponding on the Winkle surface occurred along the Benton and Linn segments of the Benton-Linn transect on December 8, 1993. The extensive ponding was limited to one location in each of the segments. Along the Linn segment the ponding was on the Awbrig soil and along the Benton segment it was on the Conser soil. Both Awbrig and Conser soils are poorly drained and are found in concave areas of low stream terraces. Because of the topographic position and low drainage gradient these soils are likely to pond when individual rain events create conditions of localized soil saturation.

The Winkle surface along the Marion county portion of the Polk-Marion transect became ponded on December 15, 1993. Soils along this one transect segment are mostly the somewhat poorly drained Clackamas and poorly drained Courtney soils, and they behave much like the soils on the Calapooyia surface. Elsewhere on this surface the soils are mostly well drained and moderately well drained, and ponding was probably more related to short term rainfall events than to cumulative total rainfall.

On the Winkle surface of the Yamhill-Marion transect extensive ponding did not occur until later in the rainy season. The Yamhill segment observations were made on the poorly drained Cove soil series. The Marion segment observations were made on the poorly drained Labish soil.

Very little ponding was observed on the Senecal surface, and there were no sites in which extensive ponding occurred. Ponding on this surface appears to be more related to short term rainfall events, as ponds are both fewer in number and of much shorter duration than on the other surfaces.

In addition to the relationship with cumulative rainfall, it would be nice to know if there is a relationship between the onset of ponding and single storm amount and intensity. This study was not designed to investigate that question, however, and the data taken from periodic transects unrelated to storm activity are simply not adequate to address this question.

Distribution of Ponds Across Geomorphic Surfaces

Summed over all transects, there were a minimum of 703 ponds observed during the study. This number was determined by counting 1 for each log entry for a single pond, 3 for each entry documenting either 2 or 3 ponds, and 4 for each entry for extensive ponding. This is probably a conservative estimate, as many sites having 4 or more ponds probably had 8 or 10 or more. Because we don't know the exact number of ponds observed, we report the data on ponding distribution as a percentage of the locations at which ponding was observed.

The distribution of ponded locations across geomorphic surfaces is summarized in Figure 3. For the Willamette valley as a whole, 50% of all locations at which ponding was observed were on the Calapooyia geomorphic surface. This figure rises to 65% for the Benton-Linn transect and is at a minimum of 36% for the Polk-Marion transect. Concentration of ponding on the Calapooyia surface corroborates our hypothesis that most of the ponding observed would occur on this surface. If there is anything surprising about these data, it is that there is as much ponding as there is on the other surfaces.

For the valley as a whole, approximately 1/3 of all ponded locations occurred on the Ingram surface, ranging from 22% along the Benton-Linn transect to 42% along the Polk-Marion transect. Because the Ingram surface is the lowest part of the regional landscape, where water tables associated with the major rivers are closest to the surface, ponding due to both standing water on poorly drained clayey soils and flooding of backwater swales is certainly to be expected.

Only about 15% of the ponded locations occurred on the Winkle surface, and less than 2% occurred on the Senecal surface. Soils on these surfaces are generally well drained, and flooding does not occur, hence ponding is much less frequent. Ponding on these surfaces is probably much more related to individual storm events than to long term saturation of the soil throughout the rainy season.

The distribution of the number of ponds observed per location across geomorphic surfaces is illustrated in Table 3. This distribution changes according to the date of observation; the data in Table 3 are for the observations on March 1, 1994, which is the date on which the maximum extent of ponding was observed.

Table 3. Distribution of the number of ponds observed per location across the geomorphic surfaces of the Willamette valley.

Surface	Number of Ponds per Location		
	1	2-3	≥ 4
<i>Ingram</i>	39%	20%	41%
<i>Winkle</i>	46%	23%	31%
<i>Calapooyia</i>	10%	21%	70%
<i>Senecal</i>	50%	50%	0%

These data clearly show that extensive ponding dominates on the Calapooyia surface, whereas the number of ponds per location is roughly equally distributed on the other three surfaces. This undoubtedly reflects the influence of the restrictive clay layer in the soils on the Calapooyia surface. At this time of the year the effects of cumulative rainfall have created perched water tables that are at or near the surface of the soil. Following a significant storm event, which did occur just prior to the March 1 observation, excess water would be expected to create widespread ponding. Soils on the other surfaces do not have such a restrictive layer, and extensive ponding is not as pronounced. Ponding on the Senecal surface is so limited that extensive ponding at any location never occurs.

Duration of Ponding

Roadway observations of ponding began in December and continued through the first week of April. During this time each transect was driven 8 times. Data collected each time indicate whether or not the ponds at a given location actually contained water. Thus we can tally how many times out of 8 possible events each location had ponded water. The data are summarized in Table 4 as the percentage of locations that contained water and in Figure 4 as the actual number of locations that contained water.

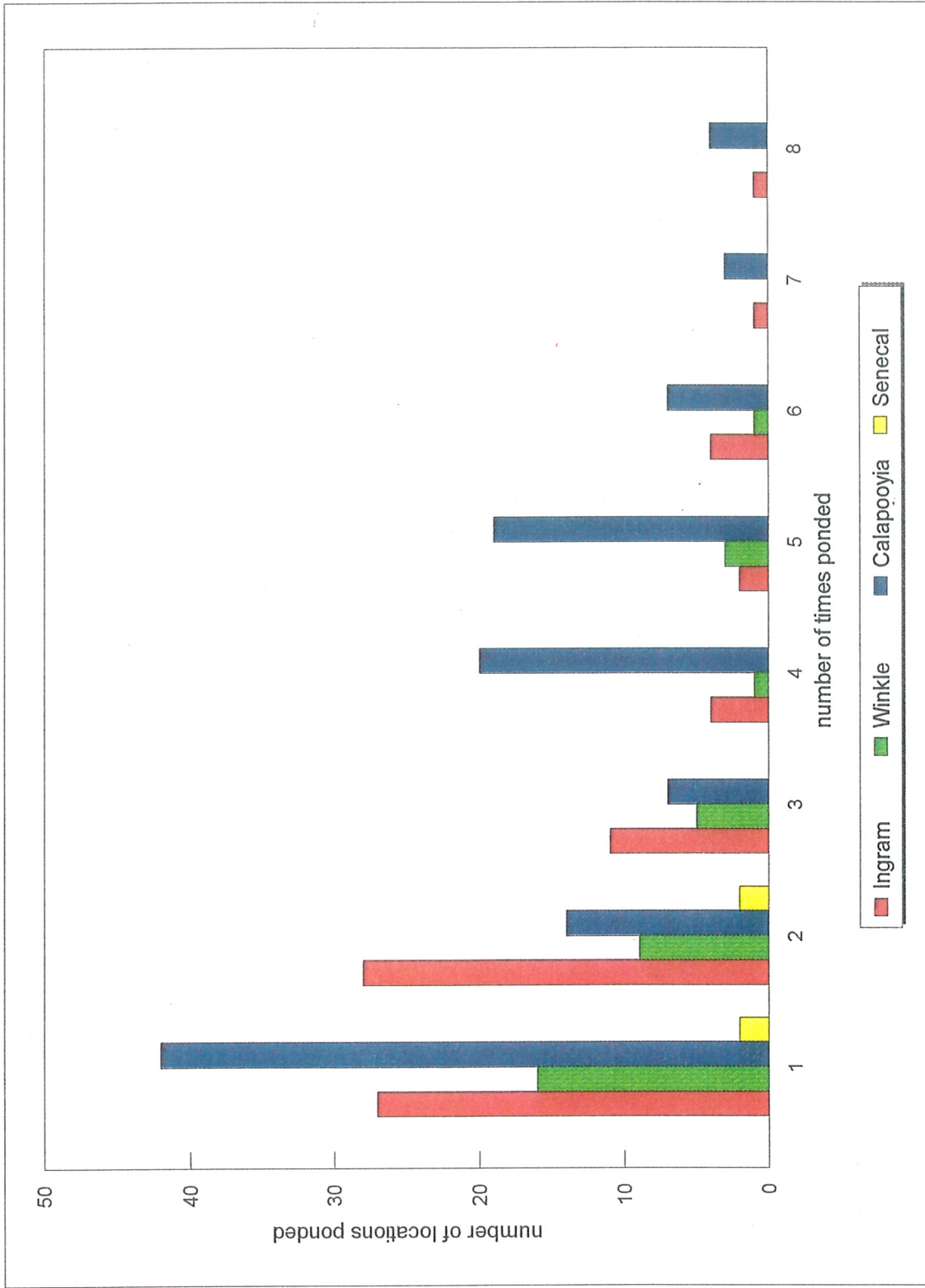


Figure 4. Distribution of the number of locations on each geomorphic surface among the number of times ponds were observed to contain water.