

# Guidelines for Extended Feature Set Markup of Friction Ridge Images

Version 0.3

12 June 2009

Working Draft in Progress for Comment and Discussion

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This document provides guidelines specifically for the use of latent print examiners in marking extended friction ridge features, for the purpose of maximizing consistency among examiners. This is a companion document to "Data Format for the Interchange of Extended Friction Ridge Features" (Draft 0.4, 12 June 2009) (EFS Specification).

This document includes more examples and specific guidance than the EFS Specification, and minimizes references to technical details of the file format. This document is not specific to any software implementation of EFS.

*This guidance document is an ongoing result of latent feature markup by Ron Smith and Associates, in coordination with Noblis. This document includes guidance that is a result of lessons learned through that process.*

*This is a rough, working draft version of a document in progress, made available for discussion and comment.*

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	A Region of Interest (ROI) delineates a single continuous friction ridge impression. Mark the region of interest to include all of the impression being evaluated, while excluding as much as possible of the background and other impressions. If in doubt be inclusive.	
<b>3</b>	<b>Orientation (Field 9.301)</b> .....	<b>7</b>
	Orientation indicates the distal direction, towards the tips of the fingers. If the image is upright, (within approximately $\pm 15^\circ$ ) it should be indicated as "Tip up". If the orientation cannot be determined, it should be indicated as "Unknown". If the orientation can be determined and the impression is not upright, the orientation should be indicated, with optional bounds of uncertainty.	
<b>4</b>	<b>Finger/Palm/Plantar Position (Field 9.302)</b> .....	<b>8</b>
	This field indicates the portion of friction ridge skin that created the impression. The position shall be noted only if the source of friction ridge skin can be definitively determined, or limited to a set of positions. If multiple positions (or finger segments) are present, each position should be outlined with a polygon. If fingerprints are off-center so that the center/core(s) are not visible, they should be indicated as tip, left side, or right side.	
<b>5</b>	<b>Pattern classification (Field 9.307)</b> .....	<b>13</b>
	Pattern classification follows the Henry system, which can be generalized to loop/arch/whorl classifications if appropriate for AFIS use. It only applies to fingerprints, not palms or lower joints. When noting the pattern classification, care should be taken to be inclusive of <b><u>all possible</u></b> pattern classes. For whorls, the whorl delta relationship (inner/outer/meeting whorl tracing) may be noted if known.	
<b>6</b>	<b>Ridge Quality/Confidence Map (Field 9.308)</b> .....	<b>14</b>

The ridge quality/confidence map is as important as any other feature in the feature set: it is the means by which the recipient can determine whether all other features are definitive or debatable. The quality/confidence is painted over the image (within the region of interest) using standard colors:

- Is any ridge information (from the impression of interest) present? ..... No= Black
- Are you **certain** of the continuity of ridge flow? ..... No= Red
- Are you **certain** of the location, presence, and absence of **all** minutiae?..... No= Yellow
- Are the ridge edge contours **clear** and **unambiguous**?..... No= Green
- Are pores **clear** and **unambiguous**?..... No= Blue
- ..... Yes= Aqua

Note particularly two critical distinctions:

- Green or better means that the presence or absence of minutiae can be used for exclusion in future comparisons — otherwise the region should be marked yellow or worse.

- Continuity of the areas marked as Yellow or better means that the impression was left as a single simultaneous impression, not a double tap, smear, or second impression — otherwise those areas must be separated by a region of red.

**7 Cores (Field 9.320)..... 24**

Cores are marked at the **focus** of the innermost recurving ridge. Note that the core is not on the innermost recurving ridgeline itself. The direction of the core is marked in the direction of ridge flow.

**8 Deltas (Field 9.321) ..... 26**

Deltas are marked at the center of the triradius, with directions marked in each of the three directions of flow. Deltas are marked in fingerprints for loops, whorls, and (when present) in tented arches. Interdigital and carpal deltas are marked for palms.

**9 Core-delta ridge counts (Field 9.322)..... 27**

For loops and whorls, a count of intervening ridges between each core and delta. If the exact count cannot be determined, a range or minimum can be defined.

**10 Lateral Center (Center Point of Reference) (Field 9.323)..... 28**

For arches, tips, and lower joints, if the centerline of the finger can be determined, the lateral center (across the finger) is marked. The location is not meaningful in the other direction (longitudinally, or along the finger). Lateral center is only meaningful if the orientation is known; the point marked is the center with respect to the orientation angle.

**11 Distinctive characteristics (Field 9.324)..... 29**

An area containing unusually discriminating/unique characteristics that cannot be defined adequately using the other features should be marked as Distinctive Characteristics. The characteristics noted in this field are specific to the friction skin itself, as opposed to issues specific to the impression. Scars, dysplasia, or other abnormalities that interfere with normal ridgeflow must be marked. Other characteristics may optionally be marked as a notation. Comments may be associated with the region as well.

**12 Minutiae (Field 9.331)..... 31**

The type of minutiae shall be marked if clearly identifiable as a ridge ending or bifurcation; otherwise, it shall be marked as unknown type. The location for a bifurcation shall be at the “Y” of the ridge, with the direction running down the valley. The location for a ridge ending or unknown type shall be at the “Y” of the valley, with the direction running up the ridge. Note that the ridge ending location corresponds with that used for the FBI’s EFTS and INCITS 378, and differs from some vendor-specific approaches. If the precise location for a ridge ending cannot be ascertained, a radius of uncertainty shall be marked to include the area of possible locations. If the type is unknown, the radius of uncertainty must be indicated.

Note the relationship between the Ridge Quality/Confidence Map (Field 9.308) and minutiae: in areas of Ridge Quality/Confidence that are green, blue, or aqua, the presence and absence of minutiae is definitive, and can be used for exclusion in future comparisons — otherwise the region should be marked yellow or red.

**13 Minutiae ridge counts (Fields 9.333) ..... 33**

Ridge counts are the intervening number of ridges between minutiae (not the intervening number + 1 used by IAFIS).

**14 Dots (Field 9.340) ..... 34**

A dot is a single ridge unit. If substantially longer local ridge width it should be marked as a standard ridge, with a pair of ridge endings. If substantially thinner than local ridge width, it should be marked as an incipient ridge.

**15 Incipient Ridges (Field 9.341) ..... 35**  
An incipient is a thin ridge unit, substantially thinner than local ridge width. An incipient is marked with a line segment along its longest dimension. If the incipient is a series of clearly separate (thin) dots, they should be marked as separate incipients. Often the distinction between a series of dots and an incipient ridge is unclear: when there is no clear answer, just mark it as one or the other.

**16 Creases and linear discontinuities (Field 9.342) ..... 36**  
Mark creases and linear discontinuities with a line segment along its length. If they curve, are feathered, or are composed of a series of crisscross creases, they should be marked as a series of line segments. All permanent (named) flexion creases should be marked and labeled: for fingerprints, the only permanent flexion crease is the Distal Interphalangeal Crease (DIP), at the base of the distal segment of a finger or thumb. Minor creases, cracks, cuts, and thin or non-permanent scars are collectively called linear discontinuities or “white lines”. They should be marked when they cross two or more ridges.

**17 Ridge edge features (Field 9.343) ..... 37**  
A protrusion (or spur) is an abrupt increase in ridge width that is not long enough to be called a bifurcation. An event on a ridge longer than local ridge width shall be marked as a standard bifurcation with a ridge ending; a shorter event shall be marked as a protrusion. Protrusions are marked at the center of the protruding area. Marking protrusions is useful because it flags an event that in another impression may elongate and become a bifurcation, or even separate and become a dot.

**18 Pores (Field 9.345) ..... 38**  
If pores are to be marked, the center of each visible pore is marked.

**19 Local Quality Issues (Field 9.357) ..... 39**  
This field is used to define one or more areas containing localized quality or transfer issues that are not fully defined using other Extended Friction Ridge Features. The problems noted in this field apply to the specific impression under consideration; issues that are specific to the friction skin itself (such as scars) are noted in Field 9.324 Distinctive Characteristics (DIS).

## 1 OVERVIEW

The extended friction ridge feature set specification (EFS)<sup>1</sup> defines a quantifiable, repeatable, and clear method of characterizing the information content of a fingerprint or other friction ridge image.

This is specifically designed to be used for casework as well as vendor-neutral AFIS searches. Uses may include, but are not limited to,

### **Analysis Casework**

Definition of the information content of a single friction ridge impression as discerned by an examiner during analysis, for archiving, interchanges with other examiners, validation and quality assurance processing, and quantitative analysis.

### **Comparison Casework**

Definition of the information content and determination of a comparison of two friction ridge impressions as discerned by an examiner during comparison and evaluation, for archiving, interchanges with other examiners, validation and quality assurance processing, and quantitative analysis.

### **AFIS Searching**

Interoperable interchange format for automated fingerprint or palmprint systems, for human-initiated searches, fully automated searches, data interchange between automated systems, and feedback to examiners from automated processing.

Note that different uses may require different subsets of the features defined here.

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<sup>1</sup> "Data Format for the Interchange of Extended Friction Ridge Features", An Addendum to ANSI/NIST-ITL 1-2007, "Data Format for the Interchange of Fingerprint, Facial, & Other Biometric Information"; WORKING DRAFT Version 0.3; 18 March 2009.

## 2 REGION OF INTEREST (ROI) (FIELD 9.300)

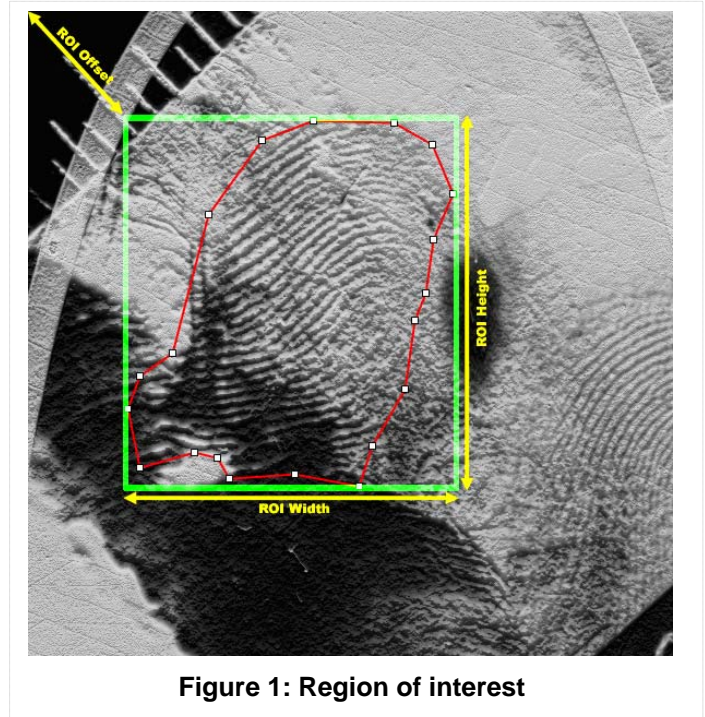
A Region of Interest (ROI) delineates a single continuous friction ridge impression. Mark the region of interest to include all of the impression being evaluated, while excluding as much as possible of the background and other impressions. If in doubt be inclusive.

The Region of Interest (ROI) is a rectangle or polygon that bounds the area of the original image containing a single friction ridge impression, and separates it from the background and any other friction ridge data present in the image. Use of a Region of Interest is strongly recommended when the overall image contains multiple impressions, or when it is difficult to differentiate between the friction ridge detail and the background.

All other features must be within the region of interest.

A region of interest shall only include one impression made by a single or contiguous portion of friction ridge skin. For example, a region of interest may be limited to a single distal fingerprint, or include multiple fingers as part of a single full palm impression, but may not include impressions of different fingers that are not connected by a common interdigital impression. In the case of overlapping fingerprints, the region of interest may include superimposed impressions.

There can only be one region of interest for a given feature set. If there are multiple impressions within a single image, more than one feature set can be marked for the image.



**Figure 1: Region of interest**

### 3 ORIENTATION (FIELD 9.301)

Orientation indicates the distal direction, towards the tips of the fingers. If the image is upright, (within approximately  $\pm 15^\circ$ ) it should be indicated as "Tip up". If the orientation cannot be determined, it should be indicated as "Unknown". If the orientation can be determined and the impression is not upright, the orientation should be indicated, with optional bounds of uncertainty.

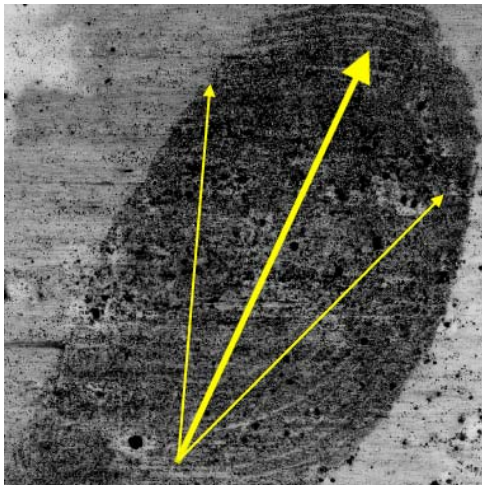
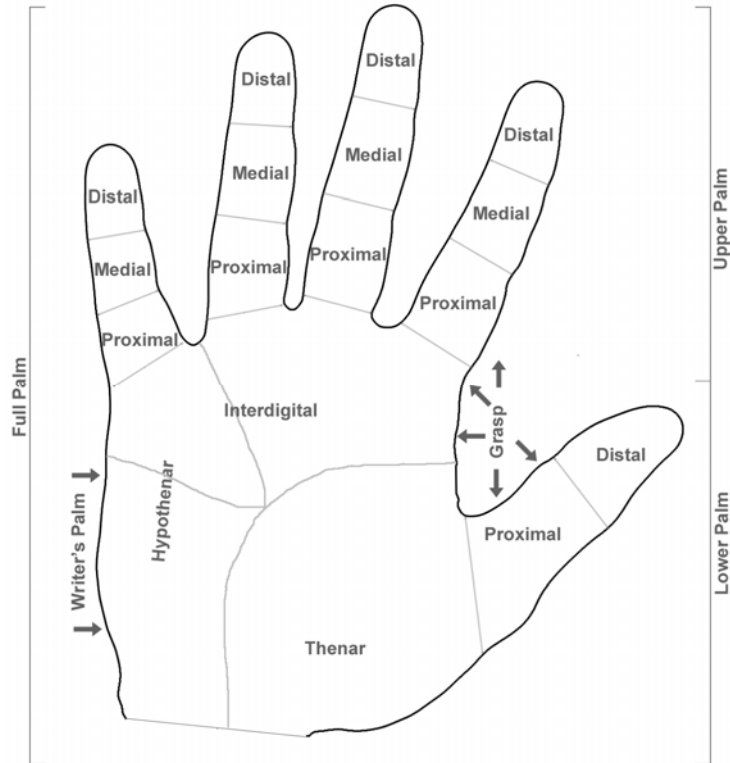


Figure 2: Orientation marked with  $\pm 15^\circ$  uncertainty

#### 4 FINGER/PALM/PLANTAR POSITION (FIELD 9.302)

This field indicates the portion of friction ridge skin that created the impression. The position shall be noted only if the source of friction ridge skin can be definitively determined, or limited to a set of positions. If multiple positions (or finger segments) are present, each position should be outlined with a polygon. If fingerprints are off-center so that the center/core(s) are not visible, they should be indicated as tip, left side, or right side.

Figure 3 shows the location divisions for a palm, and the segment locations for the fingers.



**Figure 3:** Palm and finger segment positions. Note that the interdigital and hypothenar areas overlap at the base of the little finger



<b>Table 1: Position codes for fingerprints<sup>2</sup></b>		<b>Table 2: Position codes for palms<sup>3</sup></b>		<b>Table 3: Position codes for feet<sup>5</sup></b>	
Position	Code	Position	Code	Position	Code
Unknown fingerprint	0	Unknown palm	20	Unknown sole of foot	TBD
Right thumb	1	Right full palm	21	Sole of right foot	TBD
Right index finger	2	Right writer's palm	22	Sole of left foot	TBD
Right middle finger	3	Left full palm	23	Unknown toe	TBD
Right ring finger	4	Left writer's palm	24	Right big toe	TBD
Right little finger	5	Right lower palm	25	Right second toe	TBD
Left thumb	6	Right upper palm	26	Right middle toe	TBD
Left index finger	7	Left lower palm	27	Right fourth toe	TBD
Left middle finger	8	Left upper palm	28	Right little toe	TBD
Left ring finger	9	Right other	29	Left big toe	TBD
Left little finger	10	Left other	30	Left second toe	TBD
		Right interdigital	31	Left middle toe	TBD
		Right thenar	32	Left fourth toe	TBD
		Right hypothenar	33	Left little toe	TBD
		Left interdigital	34	Front/Ball of right foot	TBD
		Left thenar	35	Back/Heel of right foot	TBD
		Left hypothenar	36	Front/Ball of left foot	TBD
		Right Grasp <sup>4</sup>	TBD	Back/Heel of left foot	TBD
		Left Grasp	TBD	Arch of right foot	TBD
				Arch of left foot	TBD

If the physical position for the image cannot be determined, the following fields shall be used:

- If the image is from a finger (including the lower joints) but the finger position is unknown, the impression shall be labeled Unknown fingerprint.
- If the image is from a palm but the location cannot be determined, Unknown palm shall be used.
- If the type of friction skin is unknown, each of the possible positions shall be included. Unknown fingerprint and Unknown palm together address all friction ridge areas on the hands; Unknown sole of foot and Unknown toe together address all friction ridge areas on the feet.

If the image/region of interest contains multiple areas, label and mark each of those areas within the region of interest, with a polygon delineating each of the areas. Polygons may overlap if appropriate. See Figure 4 and Figure 5 for examples.

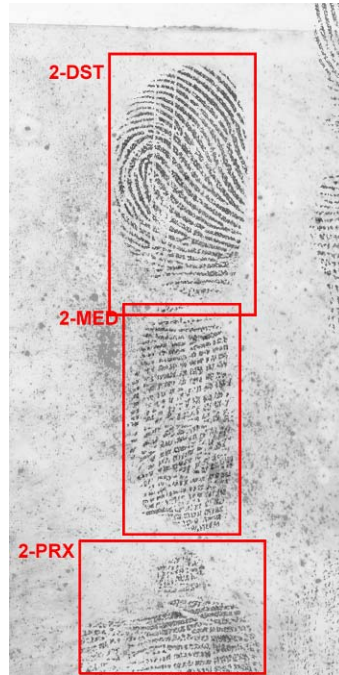
<sup>2</sup> These codes are as defined in ANSI-NIST ITL-1 2007 Table 12. Note that additional codes 11-19 are defined in ANSI-NIST ITL-1 2007 but are not applicable for these purposes.

<sup>3</sup> These codes are as defined in ANSI-NIST ITL-1 2007 Table 35, with the addition of grasp impressions.

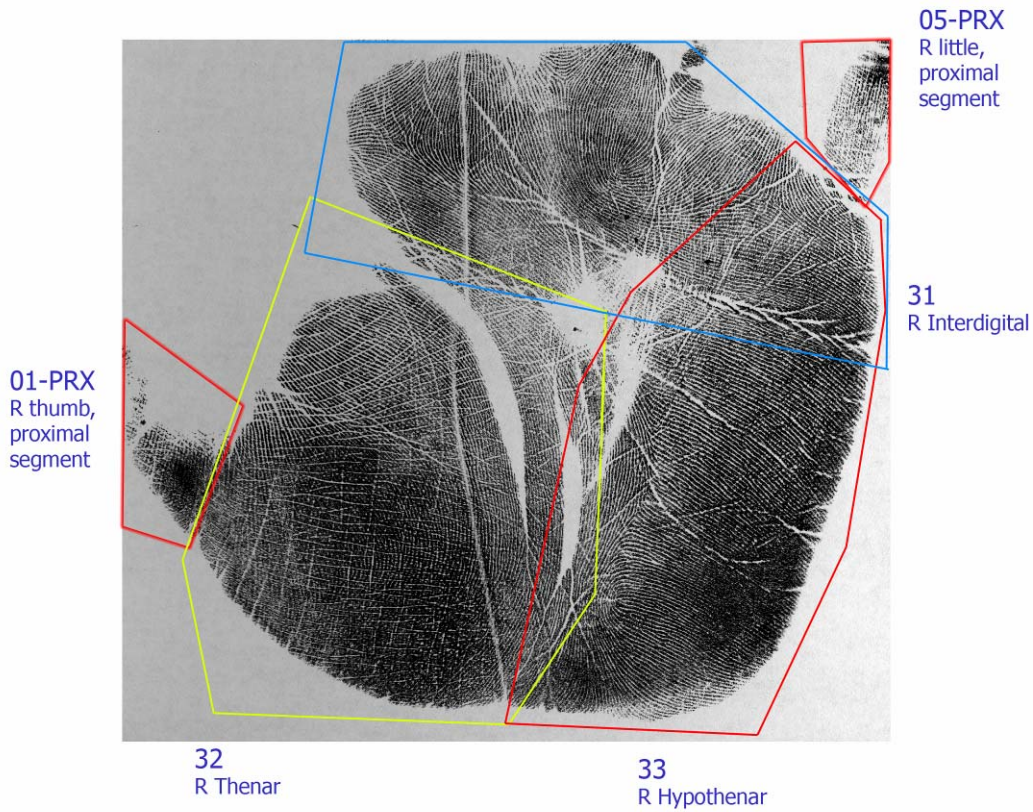
<sup>4</sup> Grasp impressions are occasionally collected as part of a set of palm prints. The traditional method of collecting grasp impressions is to wrap a fingerprint card around a cylinder and grasp it with an inked palm: the area between the thumb and index finger is collected.

<sup>5</sup> These codes are being proposed as additions to ANSI-NIST ITL-1 2007.

- If the image is an exemplar entire joint image or full finger view (from a set of complete friction ridge exemplars), or a latent of equivalent area, it shall be marked with the finger number (0-10), and shall have the individual segments marked with polygons.
- If the image is of a palm (or foot), each of the palm areas present shall be marked with the relevant position code and delineated with a polygon.



**Figure 4: Use of polygons to mark multiple finger segments in a latent equivalent to a full finger view**

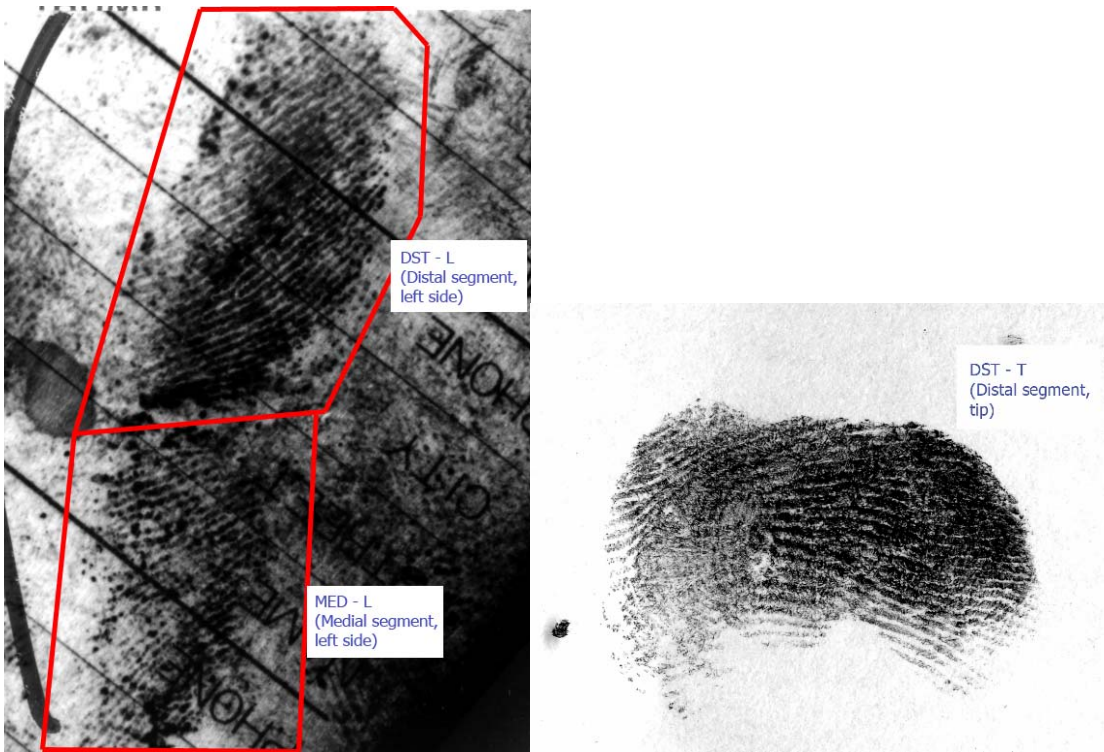


**Figure 5: Use of polygons to mark multiple areas within a palm impression**

For fingerprints in which the impression does not contain the central area of the fingerprint (e.g. the core), in which case the code from Table 4 is used to indicate the off-center position of the fingerprint image, with examples in Figure 6.

**Table 4: Off-center fingerprint positions**

Name	Code	Description
Tip	T	The plain or rolled tip of the image
Right Side	R	The right side of the finger or thumb
Left Side	L	The left side of the finger or thumb



**Figure 6:** Examples of off-center fingerprint positions

## 5 PATTERN CLASSIFICATION (FIELD 9.307)

Pattern classification follows the Henry system, which can be generalized to loop/arch/whorl classifications if appropriate for AFIS use. It only applies to fingerprints, not palms or lower joints. When noting the pattern classification, care should be taken to be inclusive of ***all possible*** pattern classes. For whorls, the whorl delta relationship (inner/outer/meeting whorl tracing) may be noted if known.



**Figure 7: Example of misleading pattern classification for a latent.**






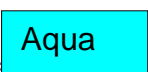
In Figure 7, the pattern classification for this print should include BOTH right loop and double loop (it is in fact a double loop). Think in terms of possible exclusions: if you have a delta and cannot otherwise classify the image, then include left loop, right loop and whorl (unspecified type).

**Table 5: Pattern classification codes**

	Pattern Classification	General Class	Subclass	Whorl Delta Relationship
<b>Arches</b>	Arch, type not designated	AU		
	- Plain Arch		PA	
	- Tented Arch		TA	
<b>Whorls</b>	Whorl, type not designated	WU		
	- Plain Whorl		PW	I, O, or M
	- Central Pocket Loop		CP	I, O, or M
	- Double Loop		DL	I, O, or M
	- Accidental Whorl	AW	I, O, or M	
<b>Loops</b>	Right Slant Loop	RS		
	Left Slant Loop	LS		
<b>Unable to print</b>	Amputation	XX		
	Temporarily unable to print (e.g., bandaged)	UP		
<b>Unable to classify</b>	Unable to Classify	UC		
	- Complete Scar	SR		
	- Dissociated Ridges/Dysplasia	DR		

## 6 RIDGE QUALITY/CONFIDENCE MAP<sup>6</sup> (FIELD 9.308)

The ridge quality/confidence map is as important as any other feature in the feature set: it is the means by which the recipient can determine whether all other features are definitive or debatable. The quality/confidence is painted over the image (within the region of interest) using standard colors:

- Is any ridge information (from the impression of interest) present? ..... No= 
- Are you **certain** of the continuity of ridge flow? ..... No= 
- Are you **certain** of the location, presence, and absence of **all** minutiae?..... No= 
- Are the ridge edge contours **clear** and **unambiguous**? ..... No= 
- Are pores **clear** and **unambiguous**? ..... No= 
- ..... Yes= 

Note particularly two critical distinctions:













- Green or better means that the presence or absence of minutiae can be used for exclusion in future comparisons — otherwise the region should be marked yellow or worse.
- Continuity of the areas marked as Yellow or better means that the impression was left as a single simultaneous impression, not a double tap, smear, or second impression — otherwise those areas must be separated by a region of red.

Local friction ridge quality is an assessment of confidence in small local areas within an image. The local quality map is used to define the confidence in all other features, and therefore is key information. In addition, when the quality map indicates a high-quality region in which features are not marked, that information can be used as “negative features” or definitive absence of features, which can be used for exclusion.

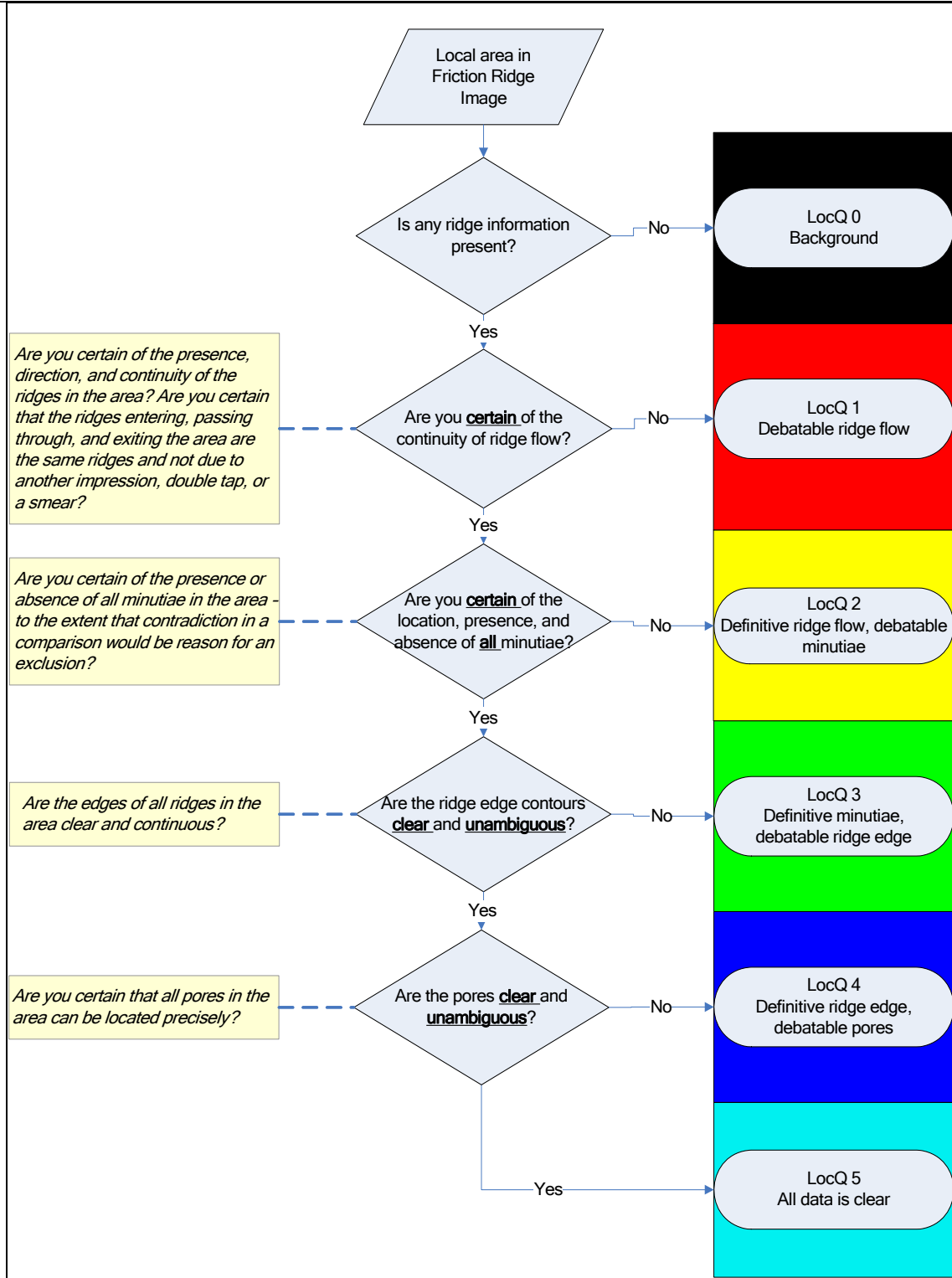
Accurate and consistent markup of local quality is essential, and the guidelines in this section should be followed as closely as possible. The names and color-coding indicated here should be used whenever possible.

<sup>6</sup> This work is based on Noblis latent quality research for the FBI Laboratory, 2007-2008, and is included with permission.

**Table 6: Definitions for ridge quality map values**

Local Quality			Ridge flow	Minutiae	Dots	Incipients	Ridge edge features	Pores	RGB values	
	0	Background	X							(0,0,0)
	1	Debatable ridge flow	?	X					(255,0,0)	
	2	Definitive ridge flow, debatable minutiae	✓	?	X				(255,255,0)	
	3	Definitive minutiae, debatable ridge edges	✓		?		X		(0,255,0)	
	4	Definitive ridge edges, debatable pores	✓				?		(0,0,255)	
	5	All features definitive	✓							(0,240,240)

<b>✓</b>	Definitive and unambiguous.	Presence, absence, and location are definitive.  Contradictory presence or absence of features in a comparison is cause for exclusion.
<b>?</b>	Debatable or ambiguous.	Features may be marked, but presence, absence, and location are debatable.  Corresponding/contradictory features in a comparison are supporting evidence for individualization/exclusion.
<b>X</b>	Not discernable or unreliable	Features should not be marked & will be ignored if present.  No evidence for individualization or exclusion in a comparison.



**Figure 8: Decision process for local friction ridge quality (LocQ)**

Figure 9 through Figure 11 show examples of local quality markup. Note that the images of local quality markup allow a person (or software program) reviewing the image a straightforward means of assessing the value and data content of the image: images with large blue areas (LocQ 4) are pristine, green areas (LocQ 3) are satisfactory, yellow areas (LocQ 2) may potentially contain false or missed features; the red areas (LocQ 1) are not of value for individualization. Overall and corresponding quality assessments are based on the size and continuity of these areas.



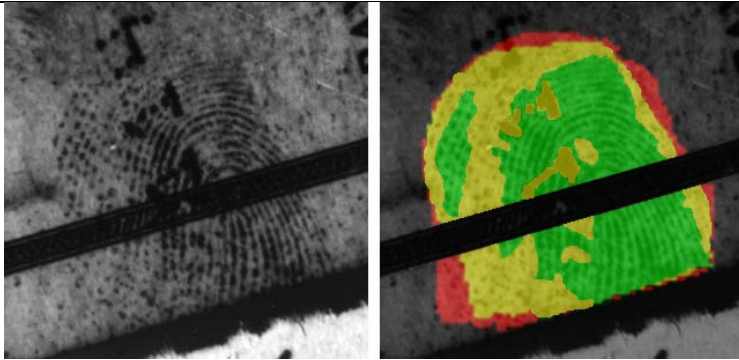


Figure 9: Local quality markup on a 500ppi latent.

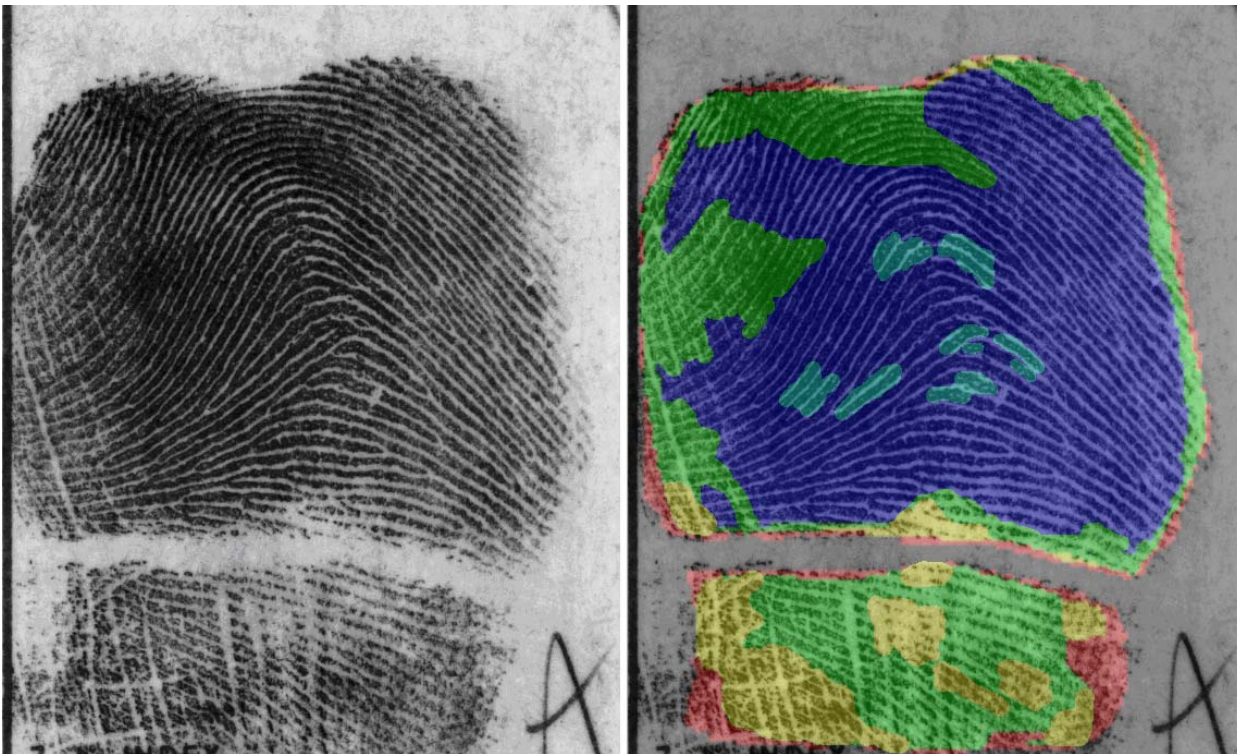


Figure 10: Local quality markup on an inked 500ppi exemplar.

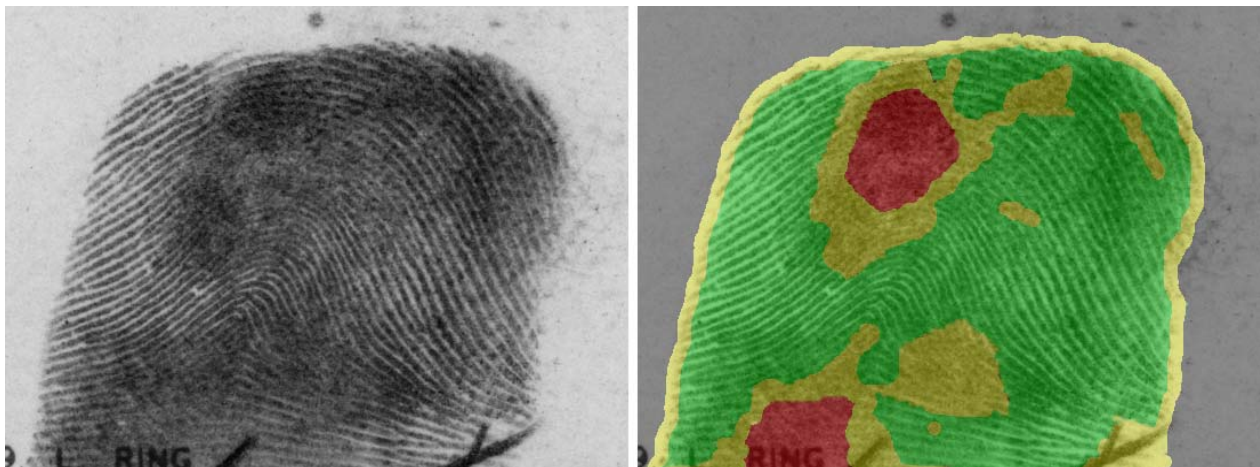


Figure 11: Local quality markup on an inked 500ppi exemplar.

While automated systems and all examiners should ideally concur on local quality markup, in practice individual examiners are likely to disagree at times. The local quality assessment by LQAS is an objective, repeatable measure of quality. An individual examiner may differ and create a different quality assessment, which is valuable in determining what that specific examiner sees in the image — but that should be used ***in addition to*** the objective automated assessment rather than replacing it.

The following sections provide examples and more detailed explanations of the levels of local quality. In each case, if there is doubt as to which level of local quality to assign, the ***lower*** quality should be used.

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**LocQ 5: All features definitive (Aqua)**  
**(Definitive ridge edges, minutiae, ridge flow, and pores)**

In the highest quality areas, ***all levels*** of ridge features are not just visible or interpretable but ***obvious and unambiguous***, including the shape and contours of ridge edges, the shape and precise location of all minutiae, dots, incipient, and pores. LocQ 5 areas are not common in exemplars or latents, and should only be marked in the specific areas in which the ***pores*** are ***obvious and unambiguous***.



Figure 12: Example of image with LocQ 5 (Clear pores)

**LocQ 4: Definitive ridge edges, debatable pores (Blue)**  
(Definitive ridge edges, minutiae, and ridge flow; debatable pores)

In LocQ 4 areas, all levels of ridge features other than the pores are not just visible or interpretable but ***obvious and unambiguous***, including the shape and contours of ridge edges, the shape and precise location of all minutiae, dots, and incipients. Pores may be absent or debatable. LocQ 4 areas are common in well-captured exemplars, but much less frequent in latents. Figure 13 and Figure 14 show examples of LocQ 4 areas. Note that LocQ 4 areas can be marked in 500ppi or 1000ppi images.



Figure 13: Examples of images with LocQ 4 (Clear ridge edge, minutiae, and ridge flow) Portions of the left image could be marked as LocQ 5, due to the clarity of pores.

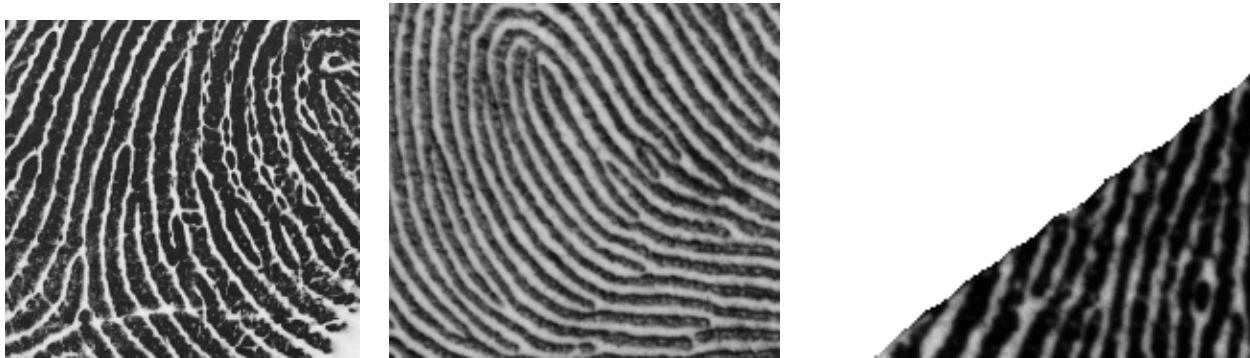
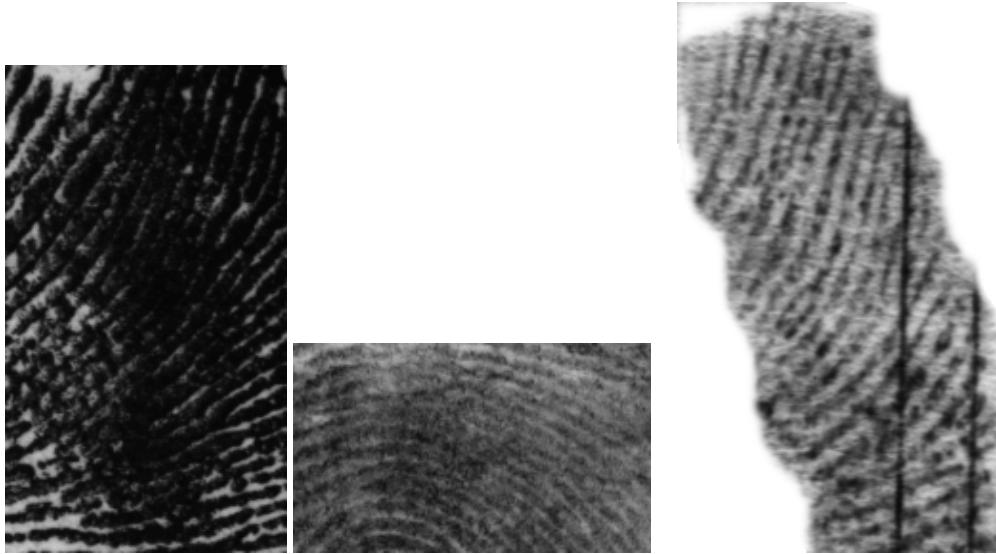


Figure 14: Examples of images with LocQ 4 (Clear ridge edge, minutiae, and ridge flow)

**LocQ 3: Definitive minutiae (Green)**  
**(Clear minutiae and ridge flow)**

LocQ 3 areas are those portions of images in which there is no doubt that any and all minutiae can be accurately detected, but without clear ridge edges. By assessing an area as LocQ 3 or better, the examiner (or software) is saying that the likelihood of false or missed minutiae in the area is remote. Minutiae in LocQ 3 areas may require limited interpretation.



**Figure 15: Examples of LocQ 3 areas (Clear minutiae and ridge flow)**



**Figure 16: Examples of LocQ 3 areas (Clear minutiae and ridge flow)**

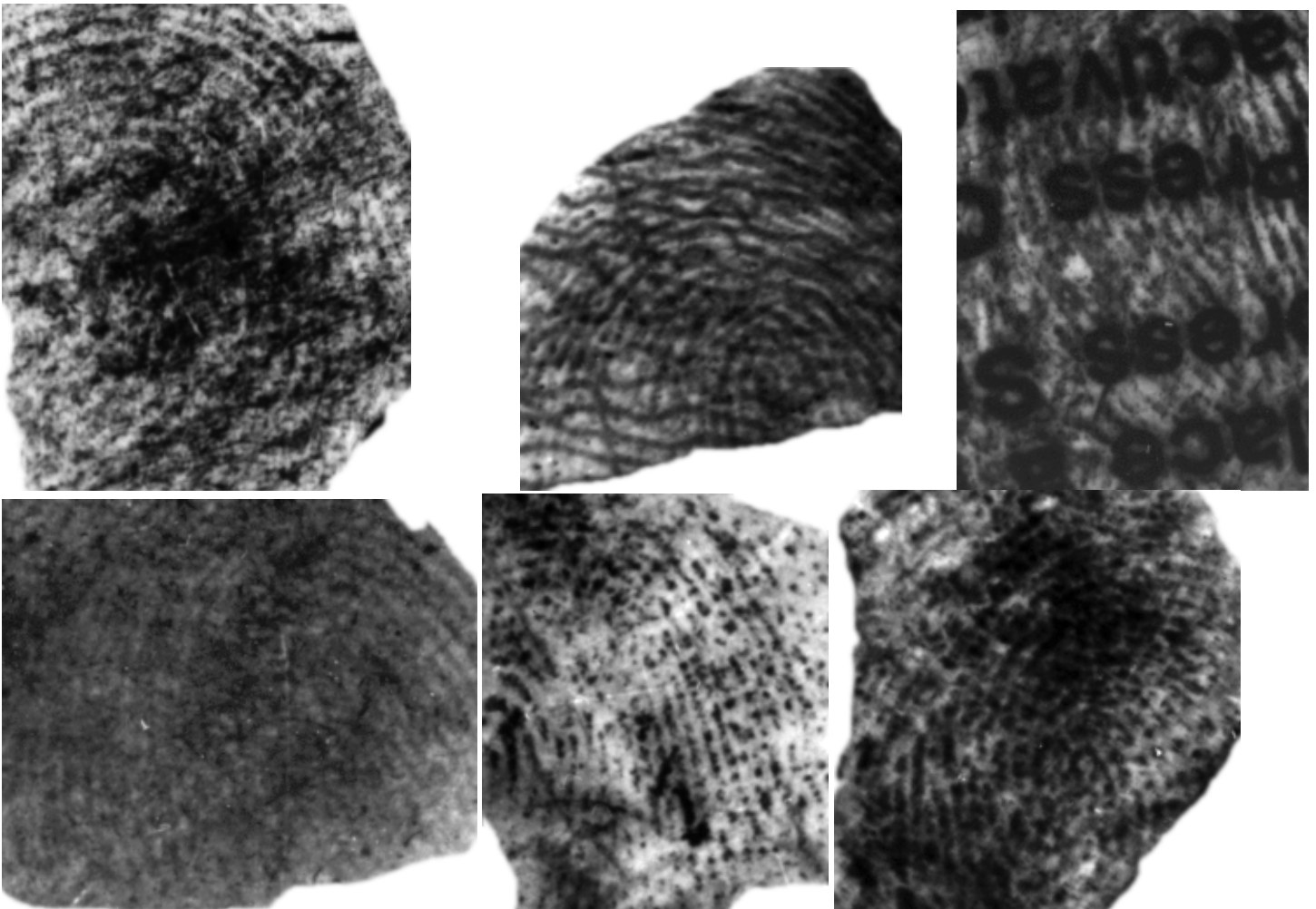
**LocQ 2: Definitive ridge flow, debatable minutiae (Yellow)**

LocQ 2 areas are those portions of images for which the examiner (or software) has confidence in the presence and direction of ridge flow, but the location and/or presence of minutiae are debatable.

By marking an area LocQ 2 instead of LocQ 3, the examiner (or software) is indicating that marked minutiae are low confidence and that areas without marked minutiae may in fact have undetected minutiae.

By marking an area LocQ 2 instead of LocQ 1, the examiner (or software) is indicating certainty that the area is from a continuous impression, and that there is no chance of a double tap or second impression. Superimposed ridge detail from two impressions can be marked LocQ 2 only if there is no doubt regarding the continuity of the ridge detail for the impression of interest.

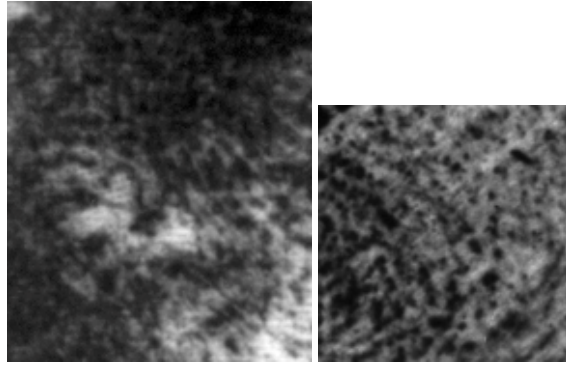
Figure 17 shows examples of LocQ 2 areas.



**Figure 17: Examples of LocQ 2 areas (Clear ridge flow but debatable minutiae)**

**LocQ 1: Debatable ridge flow (Red)**

LocQ 1 areas are those portions of images for which there is some (minimal) ridge information but for which the examiner (or software) has low or no confidence. The key point here is to indicate those areas of the image that contain ridge data but that are of insufficient quality to use in individualization. These areas are of greatest importance for images with discontinuities, as will be discussed in the next section.



**Figure 18: Examples of LocQ 1 areas (Debatable ridge flow)**

**LocQ 0: Background (Black)**

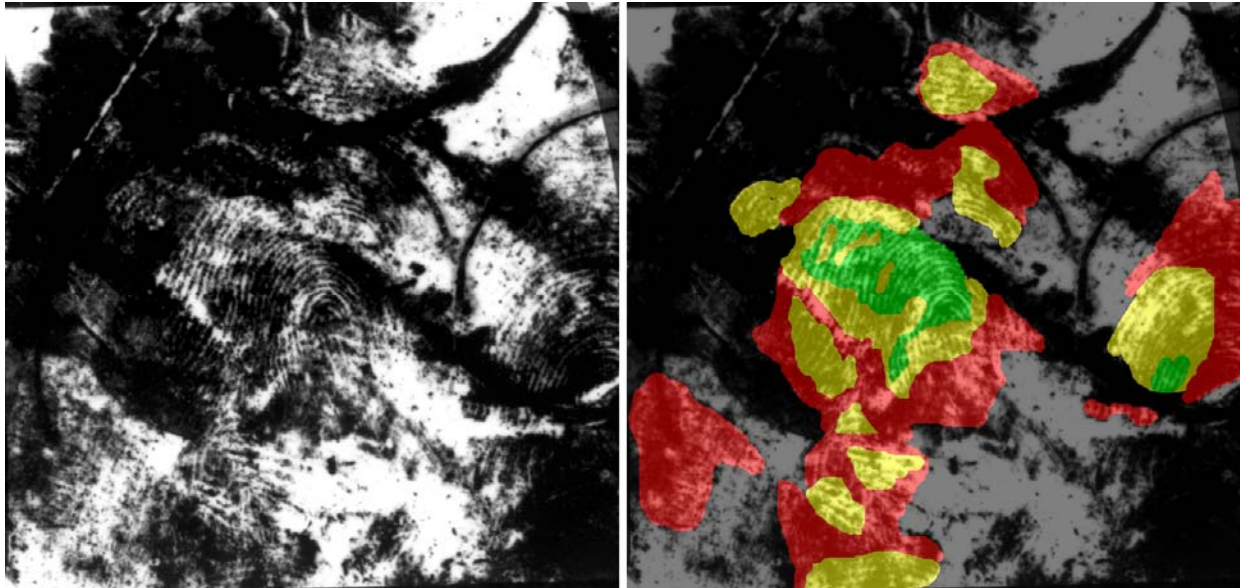
Background areas are any areas of the image that are not from the impression of interest. Any of the image outside of the Region of Interest (ROI) is by definition considered background.

## Continuity of ridge flow

Careful marking of local quality is most important for images with extensive discontinuities. In an image such as shown in Figure 19, the analysis of the image should be limited to the contiguous areas of LocQ 2 or better (yellow, green, blue). The small separations of LocQ 1 (red) are critical because those define the problem areas which can cast doubt on individualization decisions.

If there is any doubt that two portions of the image were not from a single impression (such as a double tap, smear, or second impression), those areas must be separated by LocQ 1 (red).

For minor occlusions such as printed text or lines, the area may be marked yellow if they are thin enough that it is clear which ridges on one side connect to specific ridges on the other side.



**Figure 19: Latent image with multiple discontinuous areas**

## 7 CORES (FIELD 9.320)

Cores are marked at the **focus** of the innermost recurving ridge. Note that the core is not on the innermost recurving ridgeline itself. The direction of the core is marked in the direction of ridge flow.



Figure 20: Placement of the core at the focus of the innermost recurving ridgeline, with direction in the direction of ridge flow

### Location

- Mark the core at the focus of the innermost recurving ridge. Note that the core is not on the innermost recurving ridgeline itself.

### Direction

- Mark the direction of the core in the direction of ridge flow. If the ridge is viewed as a section of a circle, the core is the center of that circle, with the direction of the core is away from the center of the curve.

### Radius of uncertainty

- If the location is known precisely, the radius of uncertainty is small
- Otherwise, the circle is sized to include other possible locations of the core, if the precise location cannot be determined due to poor clarity or ambiguity of the innermost recurving ridge

### Special cases (unusual)

- Virtual cores
  - In the special case that the core cannot be seen in the impression but a reasonable estimate of location can be made, the core can be marked in a red or even black area: these features are described as “Virtual” (defined by the location in a red or black area rather than as an explicit field).
- Direction uncertainty
  - If the core’s direction cannot be accurately determined, define a range of direction uncertainty

The core or cores of a fingerprint are defined for all pattern classifications other than plain arches, as shown in Table 7.

- Cores may be marked on tented arches if an innermost recurving ridge is present.



- Plain or central pocket loop whorls will only have one core if the innermost recurving ridge is circular, or two cores if elliptical. A whorl with only one core does not have a defined direction.
- Accidentals may have any number of cores.

For palmprints or other non-fingerprint friction ridge images, core-like patterns may be defined using this field if such structures are present.

**Table 7: Number of cores and deltas by pattern class**

	Pattern Classification	Cores	Deltas
<b>Arches</b>	- Plain Arch	0	0
	- Tented Arch	0 or 1	0 or 1
<b>Whorls</b>	- Plain Whorl	1 or 2	2
	- Central Pocket Loop	1 or 2	2
	- Double Loop	2	2
	- Accidental Whorl	N	N
<b>Loops</b>		1	1



**Figure 21: Examples of core locations for a double loop whorl, plain whorl, tented arch, and central pocket loop whorl**

TBD

## 8 DELTAS (FIELD 9.321)

Deltas are marked at the center of the triradius, with directions marked in each of the three directions of flow. Deltas are marked in fingerprints for loops, whorls, and (when present) in tented arches. Interdigital and carpal deltas are marked for palms.

The delta or deltas of a fingerprint are defined for loops and whorls. Tented arches may optionally have deltas marked if such a structure is present. Accidentals may have any number of deltas.

### Location

- Mark the delta at the center of the delta structure, where the three lines converge.

### Direction

- Mark the three directions of the delta in the three directions of ridge flow.

### Radius of uncertainty

- If the location is known precisely, the radius of uncertainty is small
- Otherwise, the circle is sized to include other possible locations of the delta, if the precise location cannot be determined due to poor clarity or ambiguity of the delta structure

### Special cases

- Virtual deltas
  - In the special case that the delta cannot be seen in the impression but a reasonable estimate of location can be made, the delta can be marked in a red or even black area: these features are described as “Virtual” (defined by the location in a red or black area rather than as an explicit field).
- Direction uncertainty
  - If the directions cannot be accurately determined, define a range of direction uncertainty for each direction.

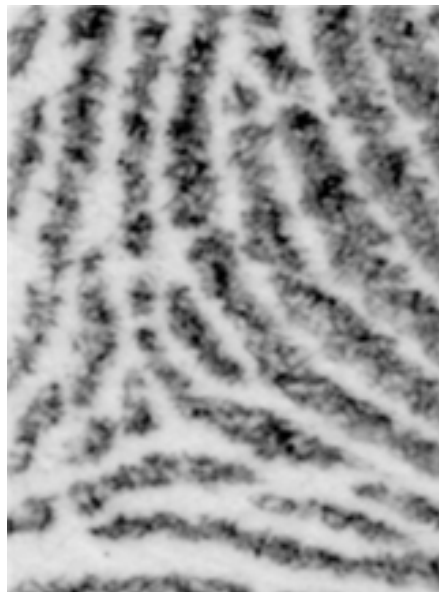


Figure 22 - Delta Example

## 9 CORE-DELTA RIDGE COUNTS (FIELD 9.322)

For loops and whorls, a count of intervening ridges between each core and delta. If the exact count cannot be determined, a range or minimum can be defined.

This field contains the count of intervening ridges between each core and delta. Each ridge count can be set as an exact value, a range, or has a minimum and maximum value, so that a range can be noted. If the exact value is known, then that value should be put in the minimum and maximum fields.

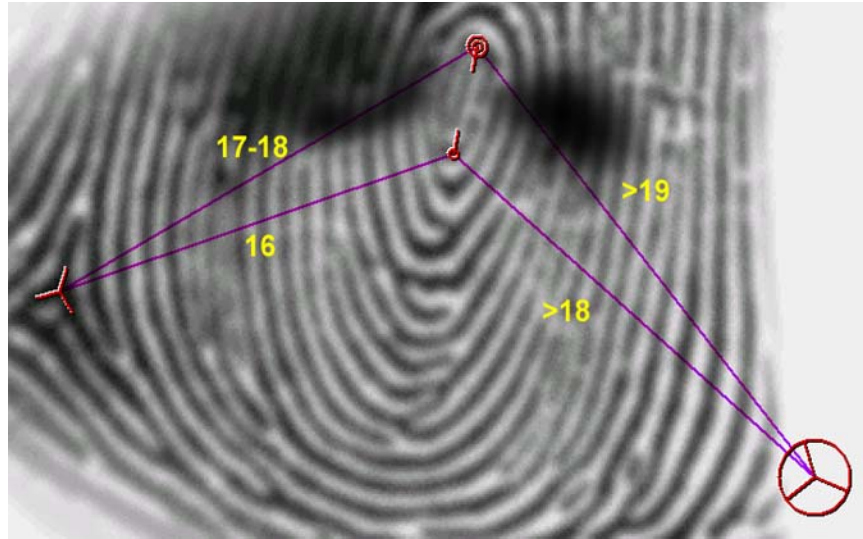


Figure 23 - Core/Delta Ridge Count Example

## 10 LATERAL CENTER (CENTER POINT OF REFERENCE) (FIELD 9.323)

For arches, tips, and lower joints, if the centerline of the finger can be determined, the lateral center (across the finger) is marked. The location is not meaningful in the other direction (longitudinally, or along the finger). Lateral center is only meaningful if the orientation is known; the point marked is the center with respect to the orientation angle.

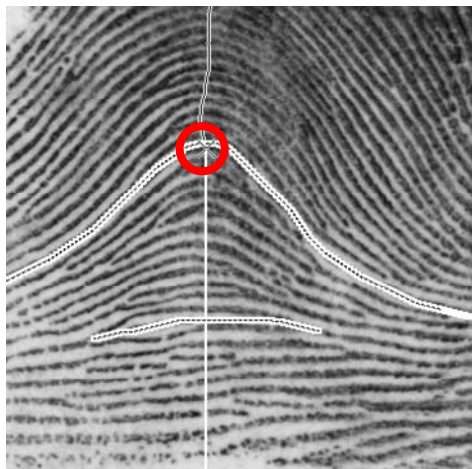


Figure 24 - Center point of reference examples

## 11 DISTINCTIVE CHARACTERISTICS (FIELD 9.324)

An area containing unusually discriminating/unique characteristics that cannot be defined adequately using the other features should be marked as Distinctive Characteristics. The characteristics noted in this field are specific to the friction skin itself, as opposed to issues specific to the impression. Scars, dysplasia, or other abnormalities that interfere with normal ridgeflow must be marked. Other characteristics may optionally be marked as a notation. Comments may be associated with the region as well.

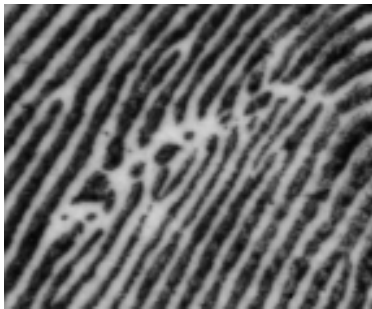
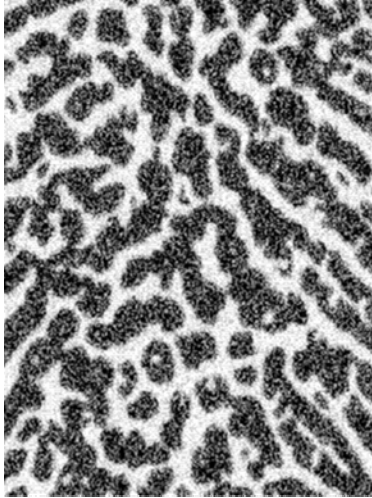


Figure 25 - Distinctive area examples

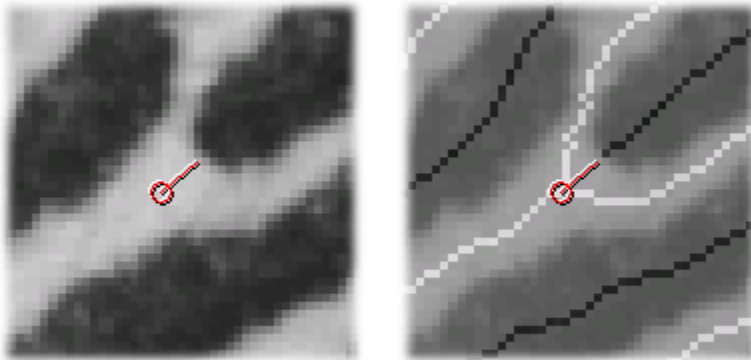
**Table 8: Types of distinctive features**

<b>Code</b>	<b>Description</b>
SCAR	Scar
WART	Wart or blister
MINGROUP	Unusual group or cluster of minutiae
CORE	Unusually distinctive core area
DELTA	Unusually distinctive delta area
MINUTIA	Unusually shaped minutia
CREASE	Unusually distinctive crease
CLEAR	Large clear field of ridges; large clear area with no minutiae
DYSPLASIA	Dissociated ridges/ Dysplasia
OTHERFEAT	Other unusual features not characterized elsewhere; details should be noted in Comments

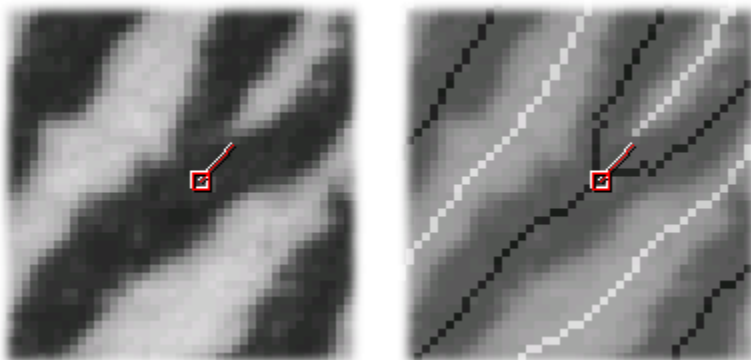
## 12 MINUTIAE (FIELD 9.331)

The type of minutiae shall be marked if clearly identifiable as a ridge ending or bifurcation; otherwise, it shall be marked as unknown type. The location for a bifurcation shall be at the “Y” of the ridge, with the direction running down the valley. The location for a ridge ending or unknown type shall be at the “Y” of the valley, with the direction running up the ridge. Note that the ridge ending location corresponds with that used for the FBI’s EFTS and INCITS 378, and differs from some vendor-specific approaches. If the precise location for a ridge ending cannot be ascertained, a radius of uncertainty shall be marked to include the area of possible locations. If the type is unknown, the radius of uncertainty must be indicated.

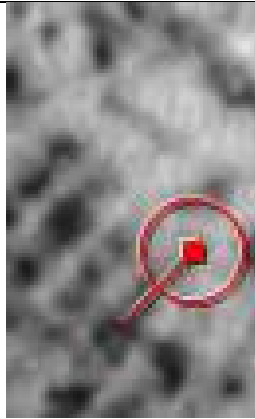
Note the relationship between the Ridge Quality/Confidence Map (Field 9.308) and minutiae: in areas of Ridge Quality/Confidence that are green, blue, or aqua, the presence and absence of minutiae is definitive, and can be used for exclusion in future comparisons — otherwise the region should be marked yellow or red.



**Figure 26: Minutia placement for a ridge ending. The center of the ridge ending should be at the “Y” of the valley. The theta angle should run up the ridge.**



**Figure 27: Minutia placement for a bifurcation. The center of the bifurcation should be at the “Y” of the ridge. The theta angle should run down the valley.**



**Figure 28:** Minutia placement when type is unknown. The minutia is placed as for a ridge ending, type is set to unknown, and the radius of uncertainty is defined to include possible points of intersection with neighboring ridges.



## **13 MINUTIAE RIDGE COUNTS (FIELDS 9.333)**

Ridge counts are the intervening number of ridges between minutiae (not the intervening number + 1 used by IAFIS).

The ridge count is the number of ridges crossed or touched on a straight line between the minutia and each of its neighbors. The count begins at zero at the minutia and increments by one for each ridge crossed. The ridge(s) which define the minutia are considered part of the minutia. For example, if one of the minutiae is a bifurcation, and if the straight line passes through one of the ridge segments forming the bifurcation, the latter is not counted separate from the minutia.

## 14 DOTS (FIELD 9.340)

A dot is a single ridge unit. If substantially longer local ridge width it should be marked as a standard ridge, with a pair of ridge endings. If substantially thinner than local ridge width, it should be marked as an incipient ridge.

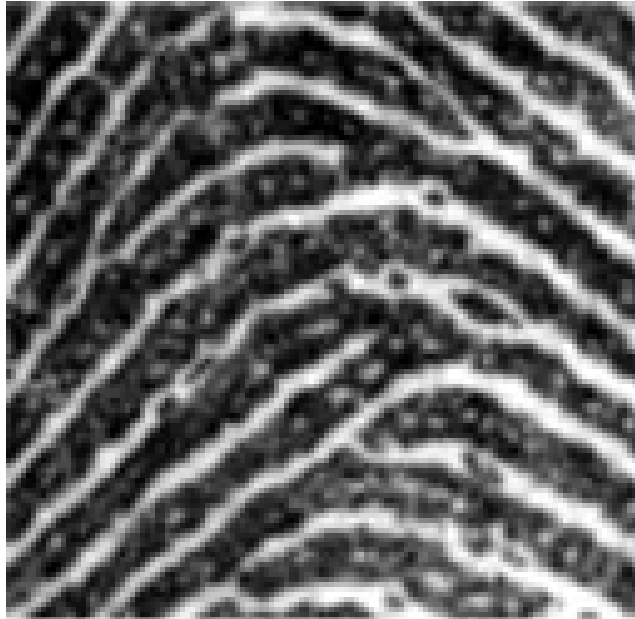


Figure 29 - Dots Example

## 15 INCIPIENT RIDGES (FIELD 9.341)

An incipient is a thin ridge unit, substantially thinner than local ridge width. An incipient is marked with a line segment along its longest dimension. If the incipient is a series of clearly separate (thin) dots, they should be marked as separate incipients. Often the distinction between a series of dots and an incipient ridge is unclear: when there is no clear answer, just mark it as one or the other.



Figure 30 - Incipient Ridges Example

## 16 CREASES AND LINEAR DISCONTINUITIES (FIELD 9.342)

Mark creases and linear discontinuities with a line segment along its length. If they curve, are feathered, or are composed of a series of crisscross creases, they should be marked as a series of line segments. All permanent (named) flexion creases should be marked and labeled: for fingerprints, the only permanent flexion crease is the Distal Interphalangeal Crease (DIP), at the base of the distal segment of a finger or thumb. Minor creases, cracks, cuts, and thin or non-permanent scars are collectively called linear discontinuities or “white lines”. They should be marked when they cross two or more ridges.

The permanent flexion creases are the named creases that separate the joints of the fingers and divide the palm. The crease name shall be noted for permanent flexion creases. For fingerprints, the only permanent flexion crease is the Distal Interphalangeal Crease (DIP), which separates the medial and distal segments of a finger, or the proximal and distal segments of the thumb.

Linear discontinuities are creases, cracks, cuts, and thin or non-permanent scars. They are often called “white lines”. Linear discontinuities result in small gaps in two or more ridges. If a continuous discontinuity curves, it should be marked as a series of adjoining line segments. If a crease is feathered or composed of a series of crisscross creases, each of the short creases shall be marked separately.



Figure 31 - Linear Discontinuity Example

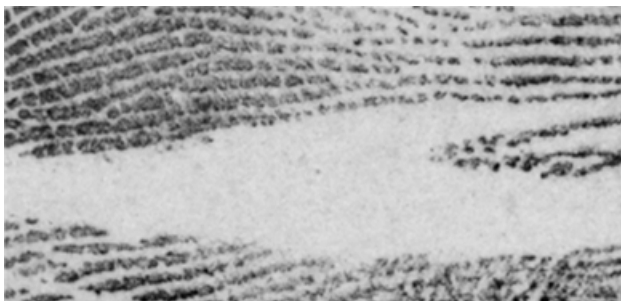
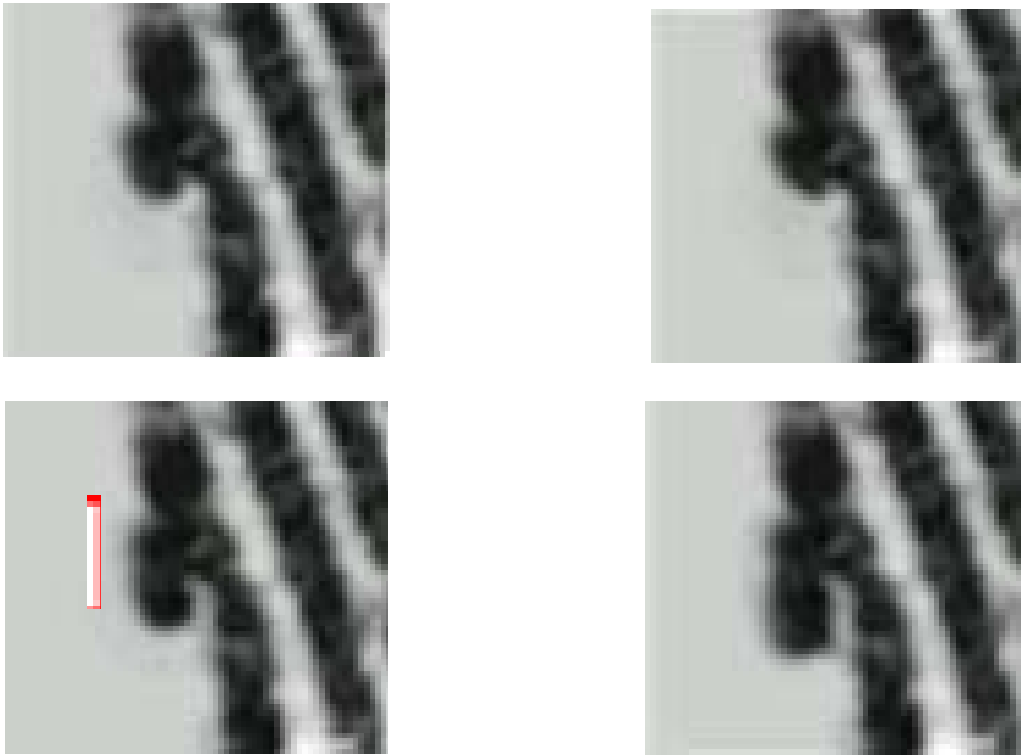


Table 9 – Major Flexion Crease Examples

## 17 RIDGE EDGE FEATURES (FIELD 9.343)

A protrusion (or spur) is an abrupt increase in ridge width that is not long enough to be called a bifurcation. An event on a ridge longer than local ridge width shall be marked as a standard bifurcation with a ridge ending; a shorter event shall be marked as a protrusion. Protrusions are marked at the center of the protruding area. Marking protrusions is useful because it flags an event that in another impression may elongate and become a bifurcation, or even separate and become a dot.



**Table 10 - Protrusion Examples: the bottom two examples are long enough to be considered bifurcations; the top two are protrusions.**

Experience with examiners showed that while protrusions are notable features, indentations and discontinuities occur so frequently and are so impression-specific (especially with respect to pores) that they are inconsequential.

## 18 PORES (FIELD 9.345)

If pores are to be marked, the center of each visible pore is marked.



Table 11 - Pores Example

## 19 LOCAL QUALITY ISSUES (FIELD 9.357)

This field is used to define one or more areas containing localized quality or transfer issues that are not fully defined using other Extended Friction Ridge Features. The problems noted in this field apply to the specific impression under consideration; issues that are specific to the friction skin itself (such as scars) are noted in Field 9.324 Distinctive Characteristics (DIS).

**Table 12: Types of quality issues**

Code	Description
ARTIFACT	Digital artifacts, such as occasionally caused by compression or livescan devices.
BACKGROUND	Interference with background makes following ridges difficult (e.g. check patterns)
COMPRESSED	Distorted area in which ridges are compressed together
DISTORT	Miscellaneous distortion (See also Compressed and Stretched)
NEGATIVE	Used if only a portion of the fingerprint image is tonally reversed (has ridges and valleys inverted so that ridges appear white and valleys appear black). Note that Tonal Inversion is used if the entire image is tonally reversed.
OVERDEV	Overdeveloped area: excessive processing medium such as ink, powder, etc.
OVERLAP	Area in which another fingerprint is superimposed over the fingerprint of interest
SMEAR	Smear or smudged area
STRETCHED	Distorted area in which ridges are stretched apart from each
OTHER	Other quality issues not characterized elsewhere; details should be noted in Comments