APPENDIX L

DETAILED ANALYSIS OF EAST AND LATERAL RUNWAY SAFETY AREA ALTERNATIVES ON TIDAL CHANNEL GEOMORPHOLOGY

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MEMORANDUM

TO: Sheri Ellis (SWCA), Patti Sullivan (FAA), Allan Heese (JNU), Randy Vigil (ACOE), Chris Meade (EPA), K Koski (NOAA), Sue Walker (NMFS), Richard Enriquez (USFWS), Carl Schrader (ADNR), Jackie Timothy (ADNR), Tom Schumacher (ADF&G), Teri Camry (CBJ)

FROM: Maureen Raad and Paul Agrimis

DATE: April 6, 2006

SUBJECT: **Further Analysis of the Potential Affects of the East and Lateral Runway Safety Area Alternatives on Tidal Channel Geomorphology**

Abbreviations

AST Alaska Standard Time
cfs cubic feet per second
DEIS Draft Environmental Impact Statement
fps feet per second
ft-mllw elevation referenced to mean lower low water vertical datum
ft-msl elevation referenced to mean sea level vertical datum
GPS Global Positioning System
lbs/sq-ft pounds per square foot
MHHW Mean Higher High Water
MLLW Mean Lower Low Water
MSL Mean Sea Level
RSA Runway Safety Area
VAI Vigil-Agrimis, Inc.
WH Wildlife Hazard

Introduction

Vigil-Agrimis Inc. (VAI) performed additional analysis on the slough system at the east end of Juneau International Airport (JNU) to better predict the effects that proposed filling of tidal channels and marshplain would have on the geomorphology of the local estuary system. The estuary geomorphology is of interest in the EIS because salmonids use these areas during their life cycles. Filling tidal channels and marshplain is being proposed to mitigate for the existing deficit in the Runway Safety Area (RSA).

Five RSA alternatives are proposed in the DEIS – RSA 1, RSA 5C, RSA 6A, RSA 6B and RSA 6C. All of the RSA alternatives propose fill to the south for the Lateral RSA and fill to the east for the East RSA. RSA 5C proposes the greatest fill volume extending the farthest into the marsh. RSA 1 and RSA 6C are in the middle in terms of both fill and extent. RSA 6A and RSA 6B propose the least fill volume extending the shortest distance into the marsh. All of the alternatives, therefore, merit additional analysis of their potential impacts. For the purpose of this memo, RSA 5C is used in the figures as it best communicates the ways in which fill and eastward extent affect the flow of water in the marsh. The three basic configurations are compared in the Analysis section of this document.

The geomorphology of an estuary system is related to the volume of water exchanged though tidal channels as a result of the change in water-surface elevations due to tides. Tidal elevations range about 24 feet in the JNU vicinity with mean higher high water (MHHW) at 11 ft-msl and mean lower low water (MLLW) at -13 ft-msl. Tides ebb and flow twice a day and tidal elevations vary both daily and seasonally. This variability combined with the relatively flat topography found on marshplains makes predicting the flow within a given channel system difficult. To address the uncertainty VAI staff performed additional analysis including:

- Establishing the order and channel classification for major channels in the East Runway Slough system,
- Developing channel profiles using HDR/Carson-Dorn survey data,
- Making flow measurements in key channels to establish likely flow distribution.

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Channel Order and Channel Classification

The channel system in the east runway vicinity caries tidal flows as well as riverine flows as shown in Figure 1. The riverine channels nearly always have some flow. These include Miller-Honsinger Slough and Dredge Slough that begin at tide gates on Miller-Honsinger Pond, and Jordan Creek. The remaining channels are tidal. Depending on their depth they can be permanently inundated or can drain completely at times. Many, including Sunny Slough and East Runway Slough, are periodically connected at high tides.

Channel order in tidal systems has been related to marsh size and the volume of water exchanged in a tidal cycle. For example, four ten-acre marshes might each support a third order system while one forty-acre marsh might support a fourth order system (Coats *et al*, 1995). The channels that drain the east runway area of the refuge were assigned drainage orders using the 2001 infrared aeria1 photography (Figure 1). Based on this assessment, East Runway Slough becomes a third order system where the second order slough connecting to Jordan Creek joins East Runway Slough. Sunny Slough becomes a third order channel where two unnamed second order sloughs join. First order channels generally drain at low tides while higher order channels provide sub-tidal habitat fringed by intertidal mudflats (Simenstad, 2000). This classification also provides a basic understanding of how tidal flows are distributed on incoming tides and drained on outgoing tides. Higher tides flow directly across the marshplain as well as in the various tidal channels.

Channel Profiles

VAI staff combined aerial photographs (c. 2001) of the slough system south and east of JNU with spot elevation data collected by HDR/Carson-Dorn in the summer of 2005 to define the major tidal flow paths between Fritz Cove and the Gastineau Channel and to determine the basic slope directions of the various channel segments. General channel slope direction is indicated with arrows in Figure 2. Larger arrows indicate a steeper slope while smaller arrows indicate a channel that is close to flat. These slope definitions are generally based on the survey elevations (Appendix A).

There is an area of higher elevation in the tidal marsh that causes the channels to drain to the east or the west as the tide recedes. These tipping points are generally located in Figure 2. This figure includes marsh vegetation communities including: open water, unvegetated tidal, low marsh and high marsh. Because there is a strong correlation between tidal marsh vegetation and the frequency and depth of tidal inundation, these areas can be used to map the frequent extents of tidal inundation. The two primary flow paths defined in the vicinity of JNU based on this assessment are illustrated in Figure 2. The primary flow path, also referred to as the major flow path, runs between East Runway Slough and Sunny Slough. The secondary, or minor, flow path is through an unnamed slough channel that runs parallel and to the north of the primary flow path.

Elevation data from HDR/Carson/Dorn along these flow paths was used to compare the relative elevations of the slough channels. This was done to determine to what extent the secondary flow path could replace the primary flow path if the primary channel system was filled. Figure 3 shows the elevations of the two flow paths from the HDR/Carson-Dorn survey with the area of highest elevation within each flow path plotted. It is likely that these elevations were not consistently recorded at the lowest part of the channel; however, they do provide a range of field surveyed elevations along the flow path.

Water in the secondary flow path generally flows from west to east. Some water enters the system through a tide gate (~4.1 ft-msl) on Miller-Honsinger Pond. The rest appears to be pushed into the system from the Gastineau Channel on the flood tide. The approximate elevation at the point where the secondary flow path joins the primary flow path is 2.2 ft-msl. The average elevation along this path is about 4.4 ft-msl but the highest point is around 5.7 ft-msl. Elevations in this range define the tipping point – the location where draining flow splits on the ebb tide.

The primary flow path transports a considerable volume of tidal water but also received some flow from Jordan Creek in the west. The lowest surveyed elevation at the west end of the flow path is about -0.5 ft-msl while the

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lowest elevation surveyed in the east is about 0.8 ft-msl. The average elevation along this path is about 2.4 ft-msl but the highest point is around 4.7 ft-msl. Elevations in this range define the tipping point on the primary flow path. The elevation difference between the two flow paths is about one-foot.

Field Assessment

VAI staff performed a field assessment in early November 2005. The objective of this field assessment was to verify the channel profile conditions and to roughly determine flow distribution in the East Runway Slough system. Field observations were made at a number of slough channel locations. These were recorded using Trimble GeoXT GPS and are illustrated in Figure 4. Four discharge measurement locations, and eight water depth and flow direction observation locations are shown in Figure 4. Two tipping points (determined from water depth and flow direction) for distributing flows east and west are also shown in Figure 4, verifying the location of the tipping points identified in the channel profile. Figure 4 also shows the photo point from which panoramic photos were taken at both high and low tides on November 8, 2005 (Figures 5 and 6).

The panoramic photographs in Figures 5 and 6 communicate the extent to which land is inundated and drained by daily tides. The high and low tide elevations for the week of the field visit are shown in Table 1. By comparing the photographs to the permanently inundated and frequently scoured areas in Figure 4, one can appreciate the large volume of water that is regularly exchanged in this system even during comparatively low winter tides.

Table 1
Tide Elevations at Time of Field Assessment

Monday 11/07/05		Tuesday 11/08/05		Wednesday 11/09/05		Thursday 11/10/05		Friday 11/11/05	
AST	ft-msl*	AST	ft-msl	AST	ft-msl	AST	ft-msl	AST	ft-msl
4:44 AM	5.00	5:56 AM	4.70	12:21 AM	-6.90	1:38 AM	-6.60	2:46 AM	-6.70
10:12 AM	-2.80	11:27 AM	-2.20	7:14 AM	5.10	8:23 AM	6.10	9:20 AM	7.40
4:11 PM	7.20			1:01 PM	-2.50	2:26 PM	-3.90	3:33 PM	-5.80
11:07 PM	-7.80	5:25 PM	6.00	6:54 PM	5.40	8:23 PM	5.50	9:37 PM	6.20

*MLLW - 8.6

Discharge measurements were made at four locations shown in Figure 4 using a flow meter and wading rod conforming generally with U.S. Geological Survey (USGS) discharge measurement standards. The measurements were made on November 8, 2005 during low tide beginning downstream with Station 1 at around 12:00 noon and ending with Station 4 at the upstream end about 2:00 p.m. (Figure 4). The discharge measurements consisted of water depth observation with the wading rod at intervals across the channel where average velocity was measured with the flow meter.

Table 2 presents the discharge measurement findings. The results are close to those expected. Station 4 is the smallest channel measured and is the furthest from Fritz Cove while Station 1 is the largest channel measured. Discharge at this station, ~24 cfs, is slightly more than the sum of the discharge measurements at Station 2 and Station 3 (~22 cfs) which contribute to the discharge at Station 1. The ~2-cfs difference (~six percent) is likely due to a couple of factors: changes in flow associated the measurements not being simultaneous, and possible wind effects at the upper measurement locations where depths were very shallow. At 12:00 noon when the field measurements were begun the tidal elevation was approximately -2 ft-msl, and by 2:00 p.m. this elevation was about 2 ft-msl. However, no backwater effect was observed. Winds were very high though, and may have affected

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vertical velocity distribution in the channels leading to under measurement of channel velocity and discharge at Station 3.

Table 2
East Runway Slough System Discharge Measurements

Station and Number	Width (feet)	Area (sq-ft)	Mean Depth (feet)	Velocity (ft/sec)	Discharge (cfs)
4. Miller-Honsinger Slough below Zig Zag	23.5	08.5	0.36	0.61	4.9
3. East Runway Slough above Jordan Creek	28.2	12.5	0.44	0.78	9.9
2. Jordan Creek below culvert	29.0	17.0	0.59	0.73	12.4
1. East Runway Slough below Jordan Creek	36.9	22.6	0.61	1.11	24.0

Analysis

Proposed safety improvements include filling of jurisdictional wetlands in the marshplain for a Runway Safety Area at the east end of the runway. Proposed RSA 5C would block the existing flows as shown in Figure 7. The proposed fill would extend east to nearly merge with the arc of dredge spoils southeast of the RSA. Two primary impacts would result from this fill without an active channel relocation to maintain the connection between Miller-Honsinger marsh and East Runway Slough:

1. Miller-Honsinger Slough and Dredge Slough flows would be diverted away from Fritz Cove and over to Gastineau Channel via Sunny Slough – resulting in an enlargement of Sunny Slough,
2. East Runway Slough would lose those contributing flows resulting in a decrease in channel size and capacity/stream order.

These impacts would occur as soon as the fill was placed and would persist.

There are secondary impacts that would occur in this estuary system as well. Those secondary impacts include:

1. The tipping points identified in Figure 2 would impede drainage leading to pooling of tidal waters upstream unless the channel profiles were modified to provide positive drainage for all tide ranges,
2. The loss of discharge from Miller-Honsinger and Dredge Slough (12 cfs as measured at low tide on November 8, 2005) would result in approximately half to two-thirds the flow (24 cfs – 12 cfs to 20 cfs – 12 cfs) in East Runway Slough below Jordan Creek (mean annual flow of approximately 8 cfs).

The pooling of tidal waters in the sloughs north of the RSA could create a new wildlife hazard. The loss of flow by the diversion might have impacts on salmonids navigating back to Jordan Creek due to changed flow conditions, or on habitat for salmonids or feed fish in this area due to the decrease in low marsh that would result from the diversion of flows.

Figure 8 compares RSA 6A or 6B, RSA 1or 6C and RSA 5C. The figure shows that opportunities for active tidal channel relocation to maintain a connection between East Runway Slough and Miller-Honsinger marsh appears stronger with alternatives RSA1, and RSA 6A or 6B. This is due to lower land surface elevation along the desired flow path and the shorter length of the flow paths. Channel relocation around the end of the RSA is possible with RSA 5C, but more excavation would be required due to higher land surface elevations along the desired flow path and the required length of the flow path.

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Conclusions

Additional analysis was performed by VAI on the slough system at the east end of JNU. This analysis included:

- Establishing the order and channel classification for major channels in the East Runway Slough and Sunny Slough systems,
- Developing channel profiles using HDR/Carson-Dorn survey data,
- Making discharge measurements in key channels associated with East Runway Slough to establish likely flow distribution.

Fieldwork for this analysis was performed by VAI staff November 7-9, 2005. Under existing conditions, due to the relative elevation and slope of the existing channels, much of the water that drains from the tide gates on Miller-Honsinger Pond flows around the end of runway 26 in East Runway Slough where it drains to the west. The area south of Miller-Honsinger Pond receives tidal flow from both the Gastineau Channel and Fritz Cove depending on the tide height. Tides greater than about 4.7 ft-msl can pass over the tipping point in the primary flow path while those greater than about 5.7 ft-msl can pass over the tipping point in the secondary flow path. Higher flows move across the marshplain directly as well as in these tidal channels.

If East Runway Slough at the end of runway 26 was filled, as proposed for the East Runway RSA alternatives, drainage from Miller-Honsinger Pond would be hampered. Tidewater and stormwater that currently drain through the Slough would back up in the existing channels (~4 ft-msl) between the proposed runway fill (~20 ft-msl) and the existing high marshplain (~16 to 20 ft-msl). Figure 7 shows RSA 5C superimposed on an air photo. The area south of Miller-Honsinger Pond would only drain when the water surface elevation exceeded the tipping point on the secondary flow path (~5.7 ft-msl). It is likely that the secondary flow path channel would eventually enlarge and deepen, though it is difficult to predict the length of time that this would take. The affect of the proposed fill on drainage is less for RSA 6A and 6B. In these alternatives, low elevation areas including marshplain and tidal channels, are not filled preserving part of the existing tidal channel network. Figure 8 shows RSA 6A which extends slightly farther into the marsh than RSA 6B.

Tidal flow reaching Dredge and Miller-Honsinger Sloughs would also be limited by the RSA fills. As with drainage this effect would be the greatest for RSA 5C and would be less for RSAs 1 and 6C and RSAs 6A and 6B respectively. In Figure 8 the marshplain is colored to show how frequently it is inundated by tidal flow. The yellow areas are inundated by peak tides and therefore do not provide frequent flow into the marsh. For tidal flow to access this area using the secondary flow path, tidal elevations would need to be greater than the defined tipping point along the secondary flow path, about 5.7 ft-msl or the existing high marshplain, between 16 and 20 ft-msl. As mentioned earlier, the tipping point on the secondary flow path is a foot higher than the tipping point on the primary flow path. Therefore, the overall effect of the proposed fill would be a decrease in the frequency of tidal channel scouring and of tidal inundation of the marshplain north of the proposed RSA fill. RSA 5C proposes fill that extends to an upland area in the marsh on which trees are growing. This effectively cuts off most tidal flow between the airport and this upland. RSA 1 and RSA 6C extend a shorter distance into the marsh. Some of the area inundated by peak tides is preserved in these alternatives.

The proposed RSA fill at the end of runway 26 would also affect the tidal channels south of the proposed RSA. These channels would adjust by decreasing in size and complexity as a result of the decrease in the volume of water and sediment moving through the system on the ebb tide. Key changes are that Sunny Slough will be the only 3rd order tidal channel system, as the East Runway Slough will downsize and become a 2nd order system. Flow in the East Runway Slough channel below Jordan Creek could decrease to approximately half to two-thirds existing flow as a result. The simplification of the tidal channel system in this area would decrease access to both high and low marsh from the tidal channel system. Loss of access to marsh fringe in the slough associated with Jordan Creek is difficult to assess in terms of how aquatic species will respond and, in turn, how salmonids in the Jordan Creek system may be impacted.

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Figure 1. Slough Channels with Channel Order (RSA 5C old)

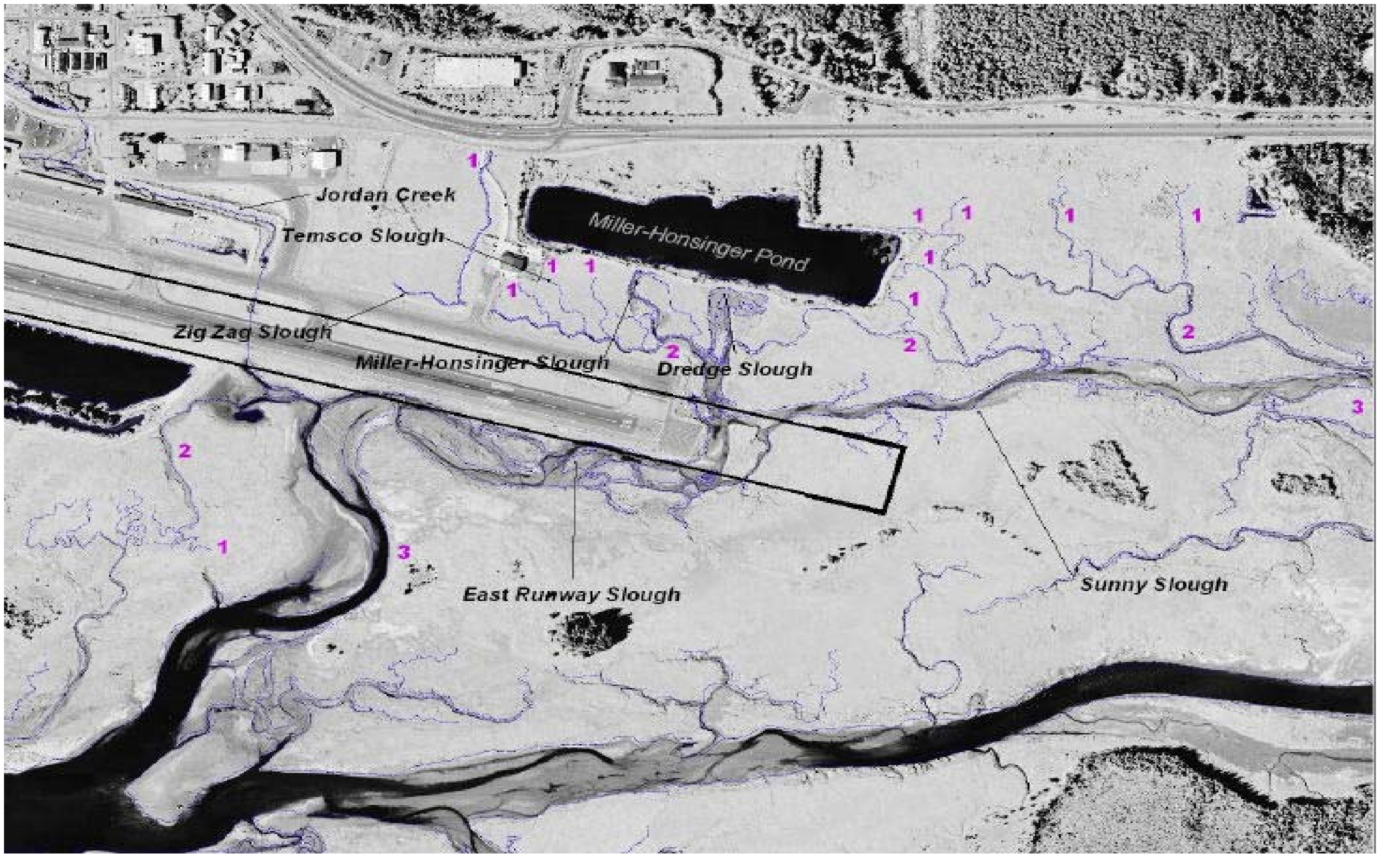

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Figure 2. Slough Channel Flow Paths and Vegetation (RSA 5C old)

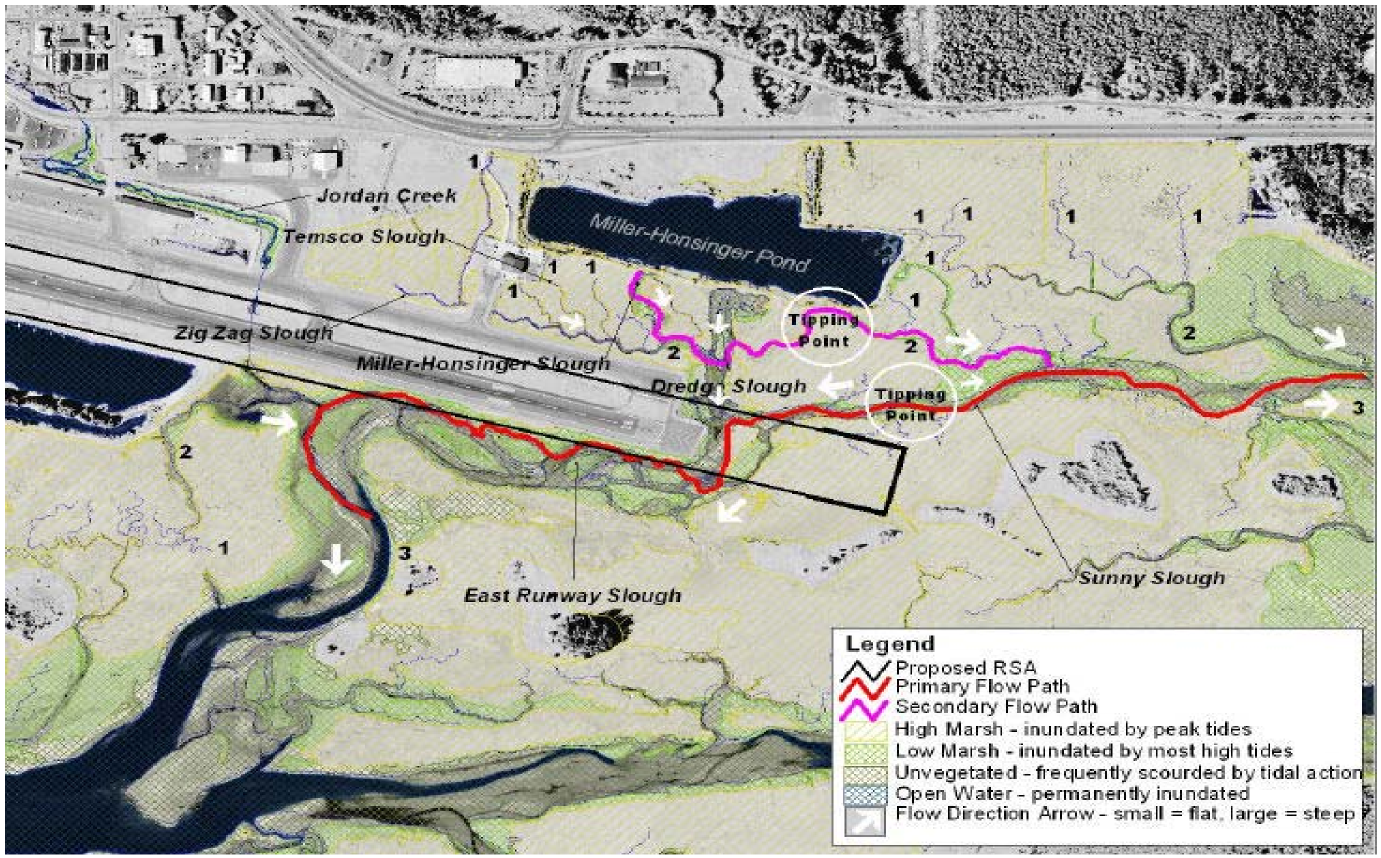

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Figure 3. Slough Channel Profile Comparison

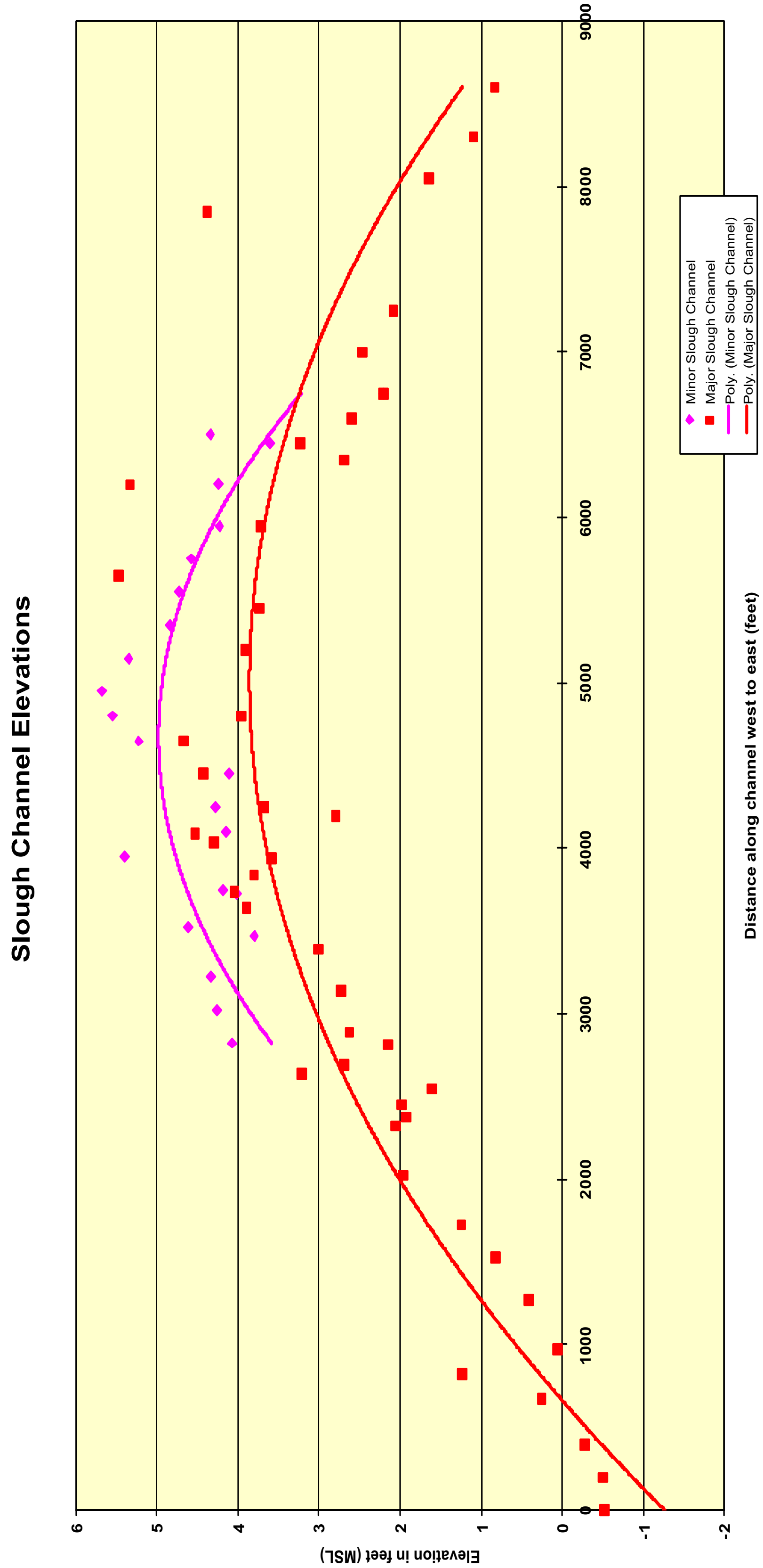

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Figure 4. Slough Channels with Field Assessment Locations (RSA 5C old)

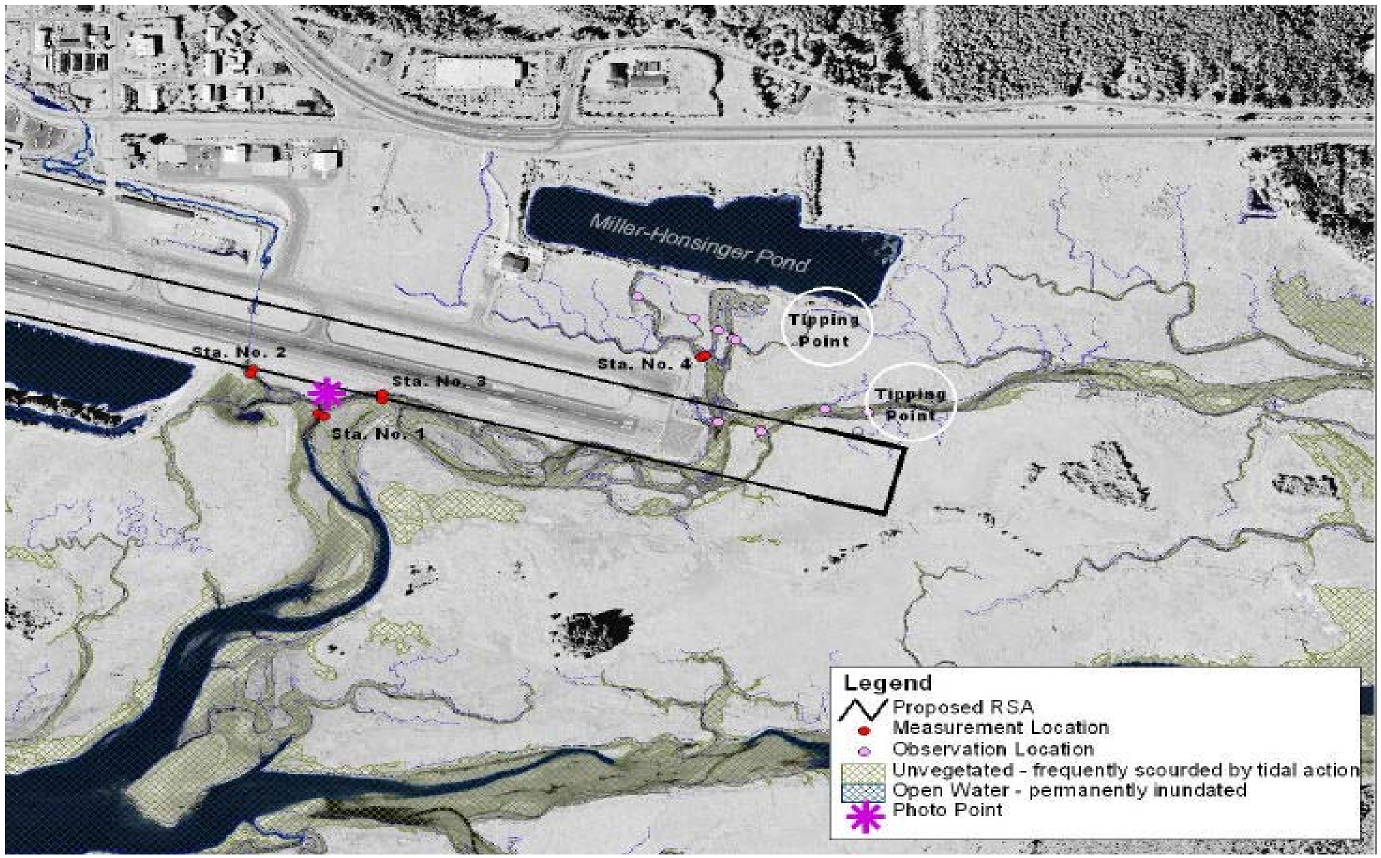

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Figure 5. Photo and High Tide about 4.5 feet MSL (~ 6:30 AM November 8, 2005)

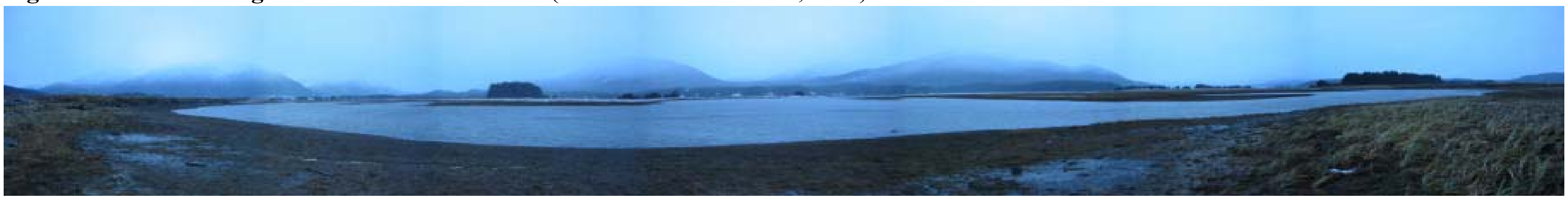

Figure 6. Photo and Low Tide about -2.0 feet MSL (~11: 30 AM November 8, 2005)

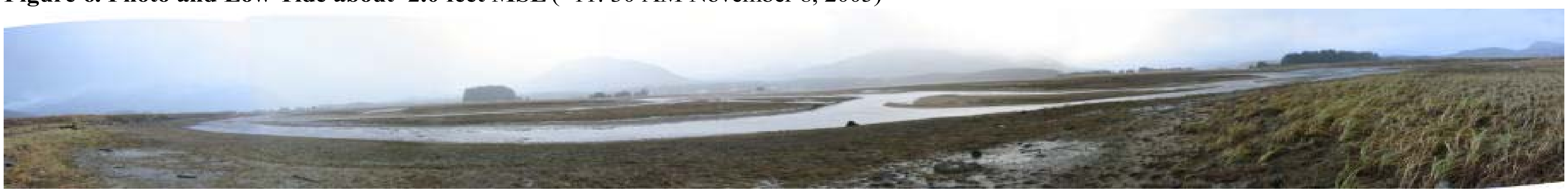

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Figure 7. Predicted Slough Channels with Channel Order (RSA 5C old)

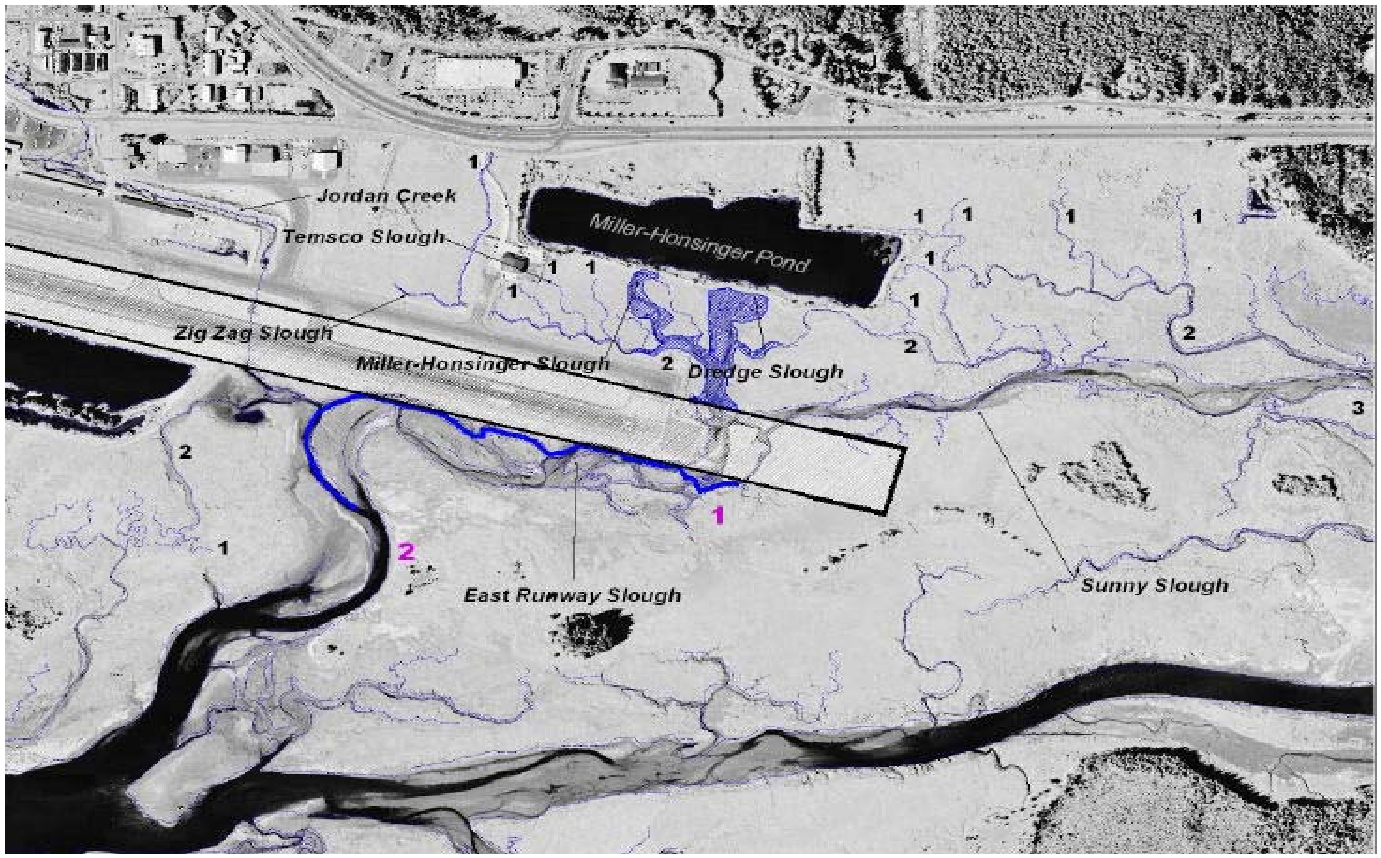

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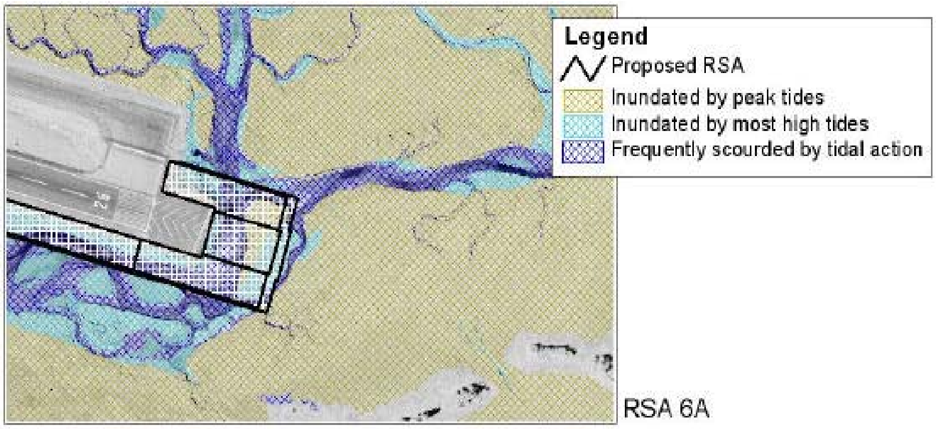
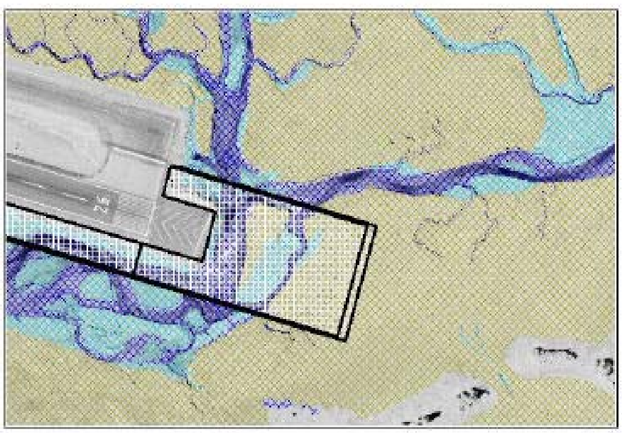
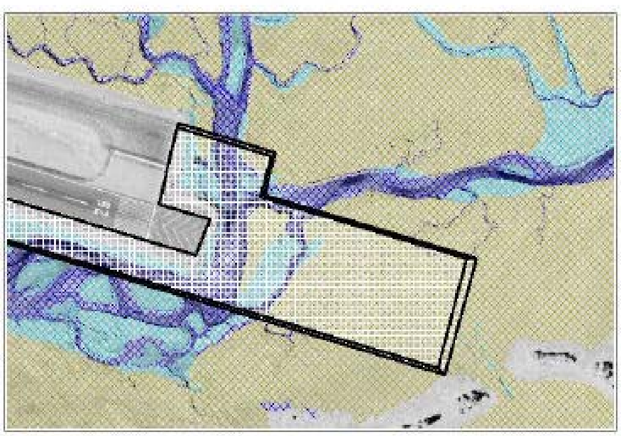
Figure 8. Comparison of East RSA extents (RSA 6A, RSA 1 or 6C and RSA 5C new)



RSA 6A



RSA 1



RSA 5C

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Appendix A

Individual channel elevation plots generated from HDR/Carson-Dorn survey data

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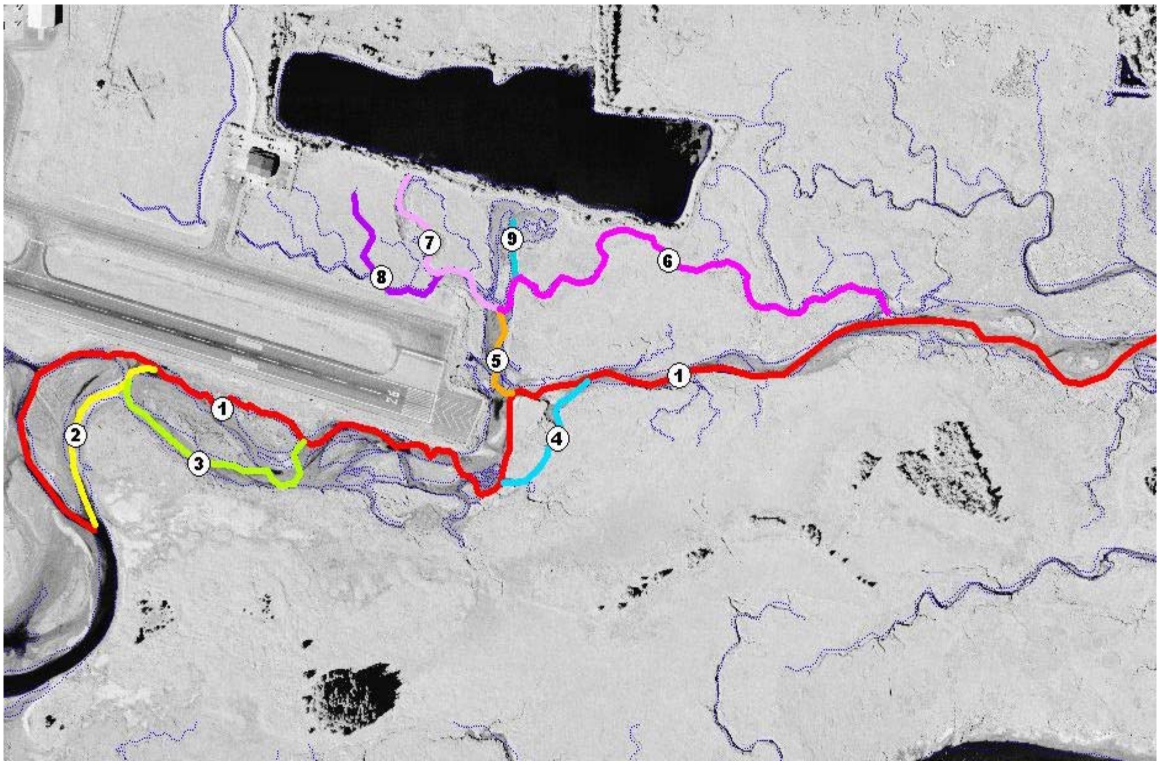
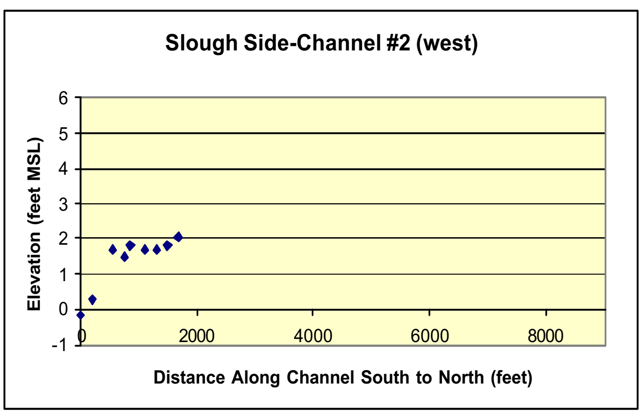
Slough Channel Locator Map





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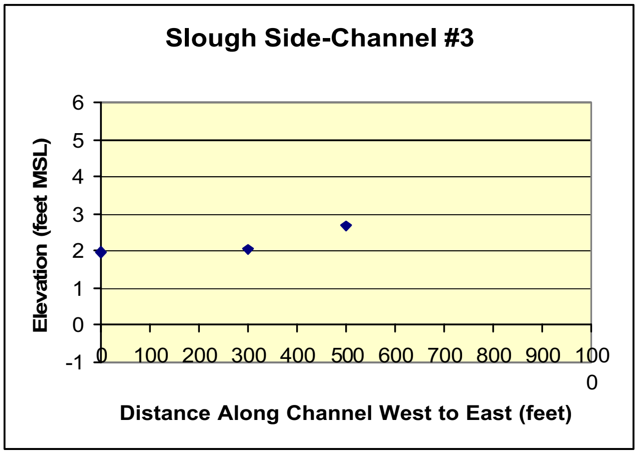

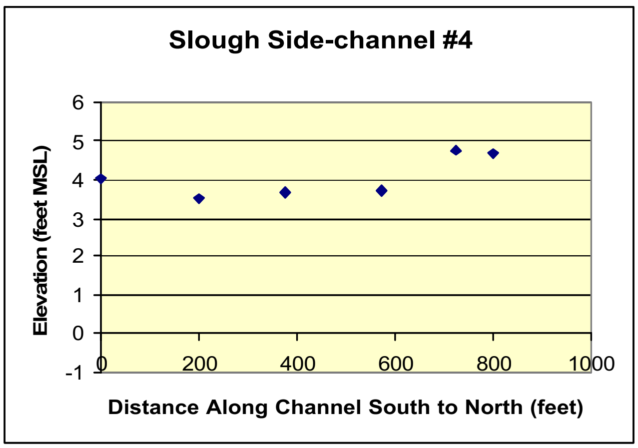

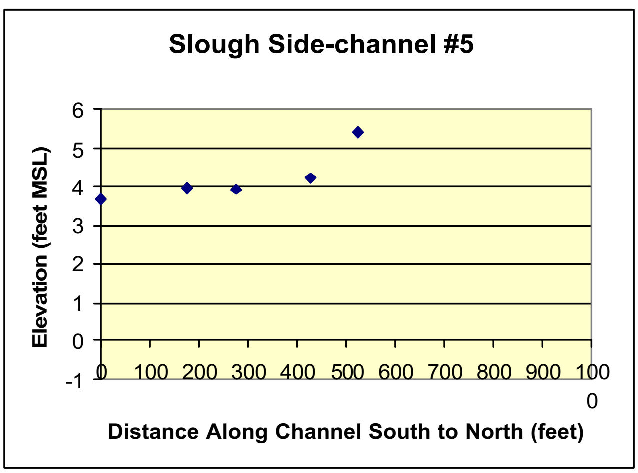

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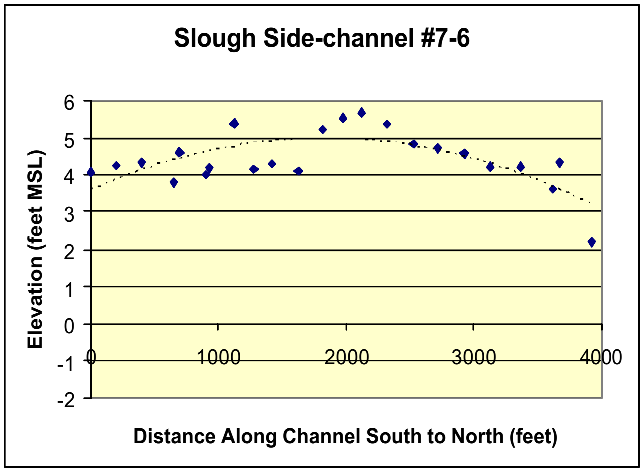

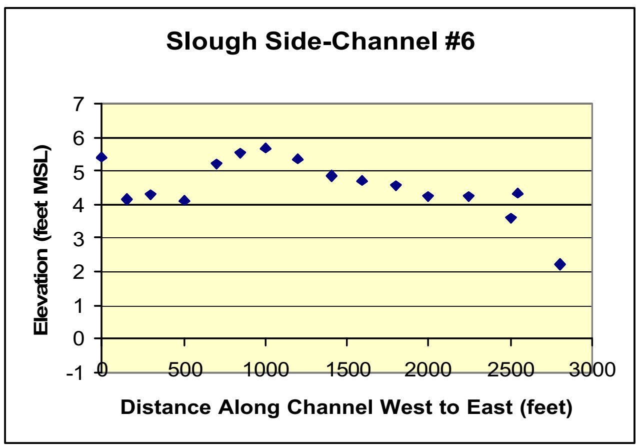

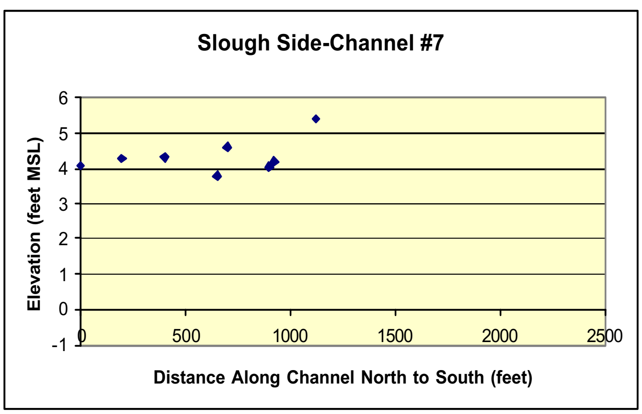

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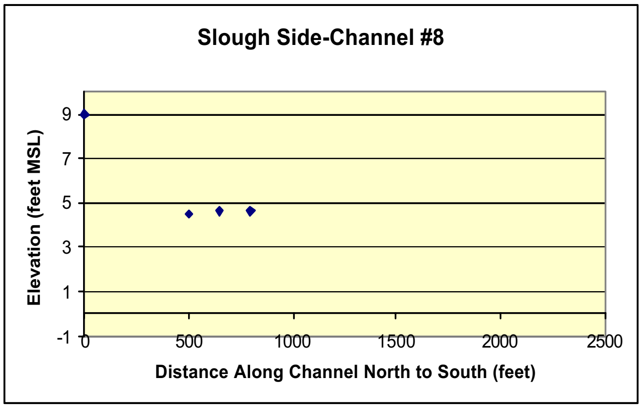

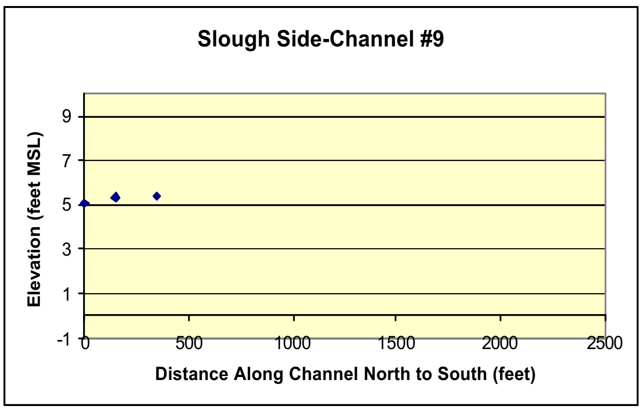

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