APPENDIX K

DETAILED ANALYSIS OF WEST RUNWAY SAFETY AREA ALTERNATIVES AND WILDLIFE HAZARD MANAGEMENT ALTERNATIVES, POTENTIAL EFFECTS ON THE HYDRAULICS AND GEOMORPHOLOGY OF THE MENDENHALL RIVER

VIGIL AGRIMIS, INC.

tel: 503-274-2010
fax: 503-274-2024
email: lmark@vigil-agrimis.com

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: Linda Mark, Maureen Raad, and Paul Agrimis

DATE: April 6, 2006

SUBJECT: **Further Analysis of the Potential Affects of the West Runway Safety Area Alternatives and Wildlife Hazard Management Alternatives on the Hydraulics and Geomorphology of the Mendenhall River**

Abbreviations

AST Alaska Standard Time
cfs cubic feet per second
DEIS Draft Environmental Impact Statement
ELJ Engineered Log Jam
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) was asked to examine potential stream channel and streambank impacts from proposed wildlife hazard management actions and Runway Safety Area (RSA) improvements at the west end of Juneau International Airport (JNU). VAI performed additional analysis on the Mendenhall River that included fieldwork. The purpose of these efforts was to better understand existing conditions and to predict the effects that proposed filling wetlands at the west end of the runway could have on the stability of the Mendenhall channel and adjacent streambank areas near the airport. Dredging was considered as a possible approach to habitat modification, as requested by several comments made by the agencies in June 2005, but our analysis suggests dredging would offer only temporary relief. Further explanation of this determination is provided later in the memo.

Filling of wetlands in the tidally influenced river floodplain is being proposed to mitigate for the existing deficit in the Runway Safety Area (RSA) and for existing and potential wildlife hazards (WH). Five RSA alternatives are proposed in the DEIS (RSA 1, RSA 5C, RSA 6A, RSA 6B and RSA 6C) with fill varying approximately 170 to 400 feet on the west end of the runway. Four WH alternatives are proposed; WH-1b, WH-2b, WH-1c, and WH-2c include filling land west of the existing runway as well.

The geomorphology of the Mendenhall River in the vicinity of JNU is affected by a combination of riverine and tidal processes. The Mendenhall River drains a 100 mi^2 watershed that is largely glaciated with mean annual discharge 1,164 cfs. Peak monthly flows occur from June through September and range from about 1,800 to 3,000 cfs. The lowest monthly flows occur from January through March and are less than 200 cfs. The Mendenhall is a geologically young river that established itself as the Mendenhall Glacier retreated. Glacial retreat has led to isostatic rebound and has caused surface uplift in the vicinity of JNU at a rate of 0.05 feet per year – about a foot every 20 years. As the River has established itself, its channel appears to have downcut at a rate of 1.5 feet over 20 years, slightly greater than the rate of surface uplift.

VIGIL AGRIMIS, INC.

tel: 503-274-2010
fax: 503-274-2024
email: lmark@vigil-agrimis.com

The mouth of Montana Creek, about 2 miles upstream of JNU, is generally acknowledged to be the upper extent of tidal influence. Tidal elevations at JNU range about 24 feet with mean higher high water (MHHW) at 11 ft-msl and mean lower low water (MLLW) at -13 ft-msl.

The Mendenhall River experienced an abrupt change in channel location (avulsion) near JNU in summer 2004. Higher than normal riverine flows and high tides combined causing the river to overtop its banks and establish a new course by cutting off a meander bend as a high tide receded. The analysis was undertaken to predict how the channel would respond to fill in the tidally influenced floodplain. Channel stability in the vicinity of the airport is an important concern for aviation operations. To address the uncertainty VAI staff performed additional analysis including:

- Locating the Mendenhall channel with Global Positioning System (GPS) following the channel avulsion to confirm channel migration since that event,
- Modifying the existing USGS HEC-RAS model for the Mendenhall River to help assess proposed fill of wetlands adjacent to the runway as a wildlife hazard management strategy.

Geomorphology Overview

The Mendenhall River is a young and vigorous stream that is well supplied with sediment from its contributing glacial discharges and landslides and avalanches that deliver cobbles, gravel, sands, silts, and colloidal clays to the channel and its tributaries. The channel meanders its way through its valley while discharging varying flows and sediment loads. Analysis of channel shape from USGS streamflow measurements conducted as part of the Water Resources Technical Working Paper prepared during the EIS indicates that the Mendenhall has sufficient stream power to keep up with the uplift that is occurring due to isostatic rebound in the region. There is a regular pattern of meanders with depositional bars and scoured pools from Mendenhall Lake to Fritz Cove. Figure 1 shows a series of scour pools and depositional bars in the vicinity of Juneau International Airport.

The large and persistent gravel bar on the channel's left bank adjacent to the west end of the runway creates a floodplain surface that supports jurisdictional wetlands. This bar is shown in Figure 1. Two other prominent bars are also evident downstream in the figure, alternating left bank, and then right bank. The wetlands on the bar at the west end of the runway are a concern for aviation safety due to flocks of large birds that rise in front of arriving and departing flights. Two potential solutions were suggested during agency meetings in spring 2005 to address the safety issue: fill and dredge.

Dredging would be a continual process due to the high sediment supply and the channel pattern (as shown by the other prominent bars in Figure 1). Channel armoring in this vicinity (protecting runway and float pond, and MALSR west of the Mendenhall) is likely to support maintenance of the channel pattern. Dredging could remove the bar for a period of time, but the river would develop a very similar bar in relatively short time by human standards, or very quickly by geologic standards (we estimate within five years). Clearly, dredging would therefore entail a periodic but relatively frequent and high-cost maintenance pattern to keep these areas as open water.

Based on those understandings of geomorphology and JNU's concerns about taking on more maintenance challenges, the focus of this memo is on providing a better understanding of how filling the wetlands that occur on the bar will affect stability of the Mendenhall River.

VIGIL AGRIMIS, INC.

tel: 503-274-2010
fax: 503-274-2024
email: lmark@vigil-agrimis.com

Field Assessment

VAI staff conducted a field visit in early November 2005. The objective of this field visit was to map changes in the location of the Mendenhall River channel following the abrupt change in channel location in summer 2004. Additional field observations were made at a number of locations. All observations were recorded on November 9, 2005 between 11:45 a.m. and 1:00 p.m. AST, using a Trimble GeoXT GPS. Tidal elevations at the time of this field visit are included in Table 1.

Table 1
Tide Elevations at Time of Field Assessment

Monday		Tuesday		Wednesday		Thursday		Friday	
11/07/05		11/08/05		11/09/05		11/10/05		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

Observations of the bank positions were recorded as lines while general observations were recorded as points. These locations are illustrated in Figure 1. In this figure, the GPS location of the river bank is superimposed over aerial photography from 2001. The aerial photography predates the change in channel location, so the overlay shows channel migration. The observed bank erosion indicated in Figure 1 shows channel migration against the east bank of the river.

The bank immediately upstream of the cutoff is eroding while material is being deposited downstream of the cutoff in the old channel. Based on the meander pattern of the Mendenhall River bank erosion could be expected in the area adjacent to the Float Plane Pond and in the area across the river from JNU at the MALSR. Not surprisingly, both of these areas have already been protected from potential erosion by riprap (Figure 1).

During the November 2005 field work a panoramic photo was taken at the location of the meander cutoff looking southwest (Figure 2). In this image the deposited sediment is visible as a broad bar in the center of the image. Earlier, photographs were taken during take off from JNU in August 2004 (Figures 3 to 5) by Mike Knapp of ADOT.

Application of Bioengineering Techniques for Bank Stabilization

Bank stabilization will be needed for the proposed fills and terrain modifications. The resource agencies have recommended investigating bioengineering design for the Duck Creek relocation, its confluence with the Mendenhall River, and the streamside slopes of the proposed fill at the west end of the runway.

Bioengineering techniques use soil, wood, rock, and in many instances living plant materials to support unstable slopes or to protect against erosion. Designs may take many forms, but in riverine settings the emphasis tends to be the use of Large Woody Debris (LWD) in Engineered Log Jams (ELJs) and log crib walls. Large wood masses can dissipate the high channel energy associated with large flow events effectively using materials considered friendlier to native fish. One hundred-year flow events on the Mendenhall mean velocities running 7-10 feet per second and 11-14 feet deep. Tidal inundation would severely limit the use of brush layering and vegetated crib walls. Roots wads and large wood members (>24" DBH and 40-60') can be used in these situations, but the buoyant forces and bending moments on wood members would be enormous, requiring deep burial and other anchoring. ELJs have

VIGIL AGRIMIS, INC.

tel: 503-274-2010
fax: 503-274-2024
email: lmark@vigil-agrimis.com

been used successfully for bank protection on even larger, more powerful, glacial rivers such as the Hoh River on Washington's Olympic Peninsula (mean annual flow 2,520 cfs, and peak flow of 54,500 cfs).

Bioengineering is feasible in all these situations, but the design and construction effort level increases substantially from Duck Creek to the Mendenhall River. Considerable information and analyses would be required to apply bioengineering techniques to protect vital transportation infrastructure along the Mendenhall. What is key to the potential successful application of bioengineering techniques on the Mendenhall is understanding the power of the river and the processes that are operating along the reach, just not the site. This is a complex setting and one where bioengineering techniques may be applicable, but likely at cost that is likely to be above that of standard treatments.

Hydraulic Modeling

VAI staff used the Hydrologic Engineering Center – River Analysis System (HEC-RAS, version 2.2) hydraulic software to model hydraulic conditions for both existing conditions (no fill) and proposed conditions (with RSA and wetland fill). The proposed conditions model is based upon DEIS alternatives RSA 6B or 6C in combination with WH-1c.

For cost and time effectiveness, VAI staff built upon an existing HEC-RAS hydraulic model that was created by the USGS to model the Mendenhall River (Neal and Host, 1999). The existing USGS model geometry is based on a combination of USGS cross-sections surveyed in September 1997 and spring 1998 (Neal and Host, 1999). VAI added five new cross-sections to the existing model. These cross-sections were defined using 2-foot LiDAR contour data (SWCA, 2001) for the land surface. The below-water portions of these cross-sections were approximated using data from neighboring USGS surveyed cross-sections and observed water depths. The source of this below-water information is as much as eight years old and conditions in the channel have likely changed during this time. Because of these dynamic channel conditions, the model results provide planning-level information on hydraulic conditions in the vicinity of the proposed changes. This level of detail is appropriate for impact assessment for the EIS; however, more detailed assessment would likely be required when the project moves to implementation.

Three of the added cross-sections (41.8, 41.5, and 41.2) are located within the area of proposed fills. The other two cross-sections (40 and 39) were added at the downstream end of the model to buffer the effect of boundary conditions on the modeling. Figure 6 shows the model cross-section locations and the proposed fill area. Because of the effects of tides both the existing and proposed conditions, the models were run under low tide and high tide conditions. MLLW (-13 ft-msl) was used as the low tide boundary condition while MHHW (11 ft-msl) was used as the high tide boundary condition.

The existing conditions cross-sections were modified based on Section 404 permit application figures 31, 32, 38, and 39 (HDR, 2005) which are included in Appendix A. As a result, cross-sections 41.8, 41.5, and 41.2 were modified. The existing model is referenced to ft-mllw vertical datum while the EIS is using ft-msl. For the purpose of this assessment elevations were converted from ft-msl to ft-mllw for use in the model. Results were then converted from ft-mllw back to ft-msl for the purpose of discussion in this memo. The conversion between the two datums is included in Table 2 for reference. Outputs from HEC-RAS have been included as appendices to this memo for reference. All elevations in these appendices reference ft-mllw

Table 2
Tidal Datums

Tidal Datum	ft-mllw	ft-msl
MHHW	19.6	11
MSL zero datum	8.6	0
MLLW	-4.4	-13

VIGIL AGRIMIS, INC.

tel: 503-274-2010
fax: 503-274-2024
email: lmark@vigil-agrimis.com

Both the existing and proposed conditions models were run for 2-, 10-, 25-, 50-, and 100-year flows for both the MLLW and MHHW tidal boundary conditions. Appendix B shows the existing conditions cross-sections in the vicinity of the proposed changes under MLLW boundary conditions for the 2-year and 100-year flow. Appendix C shows the same cross-sections under proposed conditions.

Model Results – MLLW Boundary Condition

The channel constriction, caused by the proposed fill, results in a rise in water surface elevation of about 0.4 feet for the 100-year flow under MLLW boundary conditions. This change is evident immediately upstream of the proposed fill at cross-section 42. Meanwhile, the water-surface elevation decreases by about the same amount (0.5 feet) at the downstream end of the proposed fill at cross-section 41.2 (Table 3). A more complete table of model output results is included in Appendix D.

Channel velocities decrease by as much as 0.2 fps upstream at cross-section 42 while velocities increase by as much as 2.4 fps, to 10.0 fps, at cross-section 41.2 for the 100-year event due to the channel constriction. Channel shear stress also increases modestly for the 100-year flow at cross-section 41.2 by up to 0.3 lbs/sq-ft, to 0.9 lbs/sq-ft. Channel shear stress is a calculation of the force that moving water exerts on the channel bed sediment (force/area=stress). Shear stress increases as channel flow becomes steeper or deeper; engaging larger channel bed sediment to move downstream. Shear stress of 1 will initiate movement of cobble sized material (4-inch).

The model shows minor effects upstream between cross-sections 44 and 48. Minor effects on water surface elevations are defined as changes of 0.2 feet or less and/or velocity changes of 0.2 fps or less. Downstream of the proposed fill (below cross-section 41.2), the river hydraulics are not affected.

In both the existing- and proposed-condition models, Froude numbers near 1.0 occur at cross-section 39, indicating the potential for unstable hydraulic conditions at this location. The Froude number is a ratio of velocity to gravity forces, and a ratio of one indicates a tenuous stability. Interestingly, cross-section 39 is closest to the site of the meander cutoff that occurred in summer 2004. Channel Froude numbers are not changed by more than 0.1 anywhere in the model due to the proposed changes, indicating that the degree of hydraulic stability of the channel is not changed much by the proposed fill. Active erosion was observed downstream of this cross-section during the November 2005 fieldwork.

The increase in water surface elevation upstream of the proposed fill that is indicated by the model will warrant further analysis in the design phase. This will likely entail updating channel data and refining the design. Design refinements could include modifying the shape of the proposed fill or excavating on the opposite bank of the Mendenhall River to mitigate for floodplain constriction caused by the proposed fill. However, this estimated increase in water surface elevation due to the proposed fill is minor compared to the increase in water surface elevation due to natural tidal conditions at the site.

VIGIL AGRIMIS, INC.

tel: 503-274-2010
fax: 503-274-2024
email: lmark@vigil-agrimis.com

Table 3a
Existing Conditions with MLLW Tidal Boundary Condition (-13 ft-msl)

Cross-Section	Flow Conditions	W.S. Elevation (ft-msl)	Hydraulic Radius (ft)	Velocity Channel (ft/s)	Shear Channel (lb/sq ft)	Top Width (ft)	Froude # Channel
49	2-year	8.84	6.68	5.48	0.43	256	0.37
49	100-year	13.0	8.82	6.56	0.57	345	0.38
48	2-year	8.37	8.09	4.76	0.27	242	0.29
48	100-year	12.3	10.6	6.75	0.49	278	0.36
47	2-year	7.94	7.78	5.41	0.33	223	0.34
47	100-year	11.5	10.7	7.87	0.62	236	0.42
46	2-year	7.83	8.30	5.02	0.26	226	0.30
46	100-year	11.4	11.3	7.50	0.52	236	0.39
45.5	Bridge						
45	2-year	7.77	7.92	5.13	0.31	232	0.32
45	100-year	11.4	10.8	7.53	0.61	246	0.40
44	2-year	7.58	6.80	5.41	0.27	257	0.36
44	100-year	11.2	9.69	7.48	0.46	277	0.42
43	2-year	6.91	7.65	4.78	0.20	258	0.30
43	100-year	10.2	9.78	7.05	0.41	292	0.39
42	2-year	6.41	10.7	4.63	0.17	1300	0.24
42	100-year	8.93	12.7	8.05	0.49	1350	0.39
41.8	2-year	6.00	7.38	5.34	0.24	699	0.31
41.8	100-year	8.08	3.81	8.94	0.64	1180	0.47
41.5	2-year	5.95	4.84	4.22	0.15	920	0.25
41.5	100-year	8.16	6.00	6.54	0.34	1090	0.35
41.2	2-year	5.55	4.48	5.00	0.27	421	0.41
41.2	100-year	7.39	6.05	7.60	0.55	440	0.53
41	2-year	3.88	3.12	8.77	0.78	375	0.67
41	100-year	6.08	2.23	9.32	0.90	1300	0.73
40	2-year	3.51	2.88	5.90	0.39	683	0.51
40	100-year	4.85	3.68	8.12	0.69	806	0.64
39	2-year	2.42	1.84	8.79	0.99	717	0.96
39	100-year	3.69	2.56	9.92	1.18	922	0.98

VIGIL AGRIMIS, INC.

tel: 503-274-2010
fax: 503-274-2024
email: lmark@vigil-agrimis.com

Table 3b
Proposed Conditions with MLLW Boundary Conditions (-13 ft-msl)

Cross-Section	Flow Conditions	W.S. Elevation (ft-msl)	Hydraulic Radius (ft)	Velocity Channel (ft/s)	Shear Channel (lb/sq ft)	Top Width (ft)	Froude # Channel
49	**2-year**	8.79	6.68	5.52	0.44	255	0.37
49	**100-year**	13.1	8.94	6.47	0.55	346	0.38
48	**2-year**	8.32	8.05	4.79	0.27	241	0.29
48	**100-year**	12.4	10.7	6.65	0.48	279	0.35
47	**2-year**	7.87	7.72	5.46	0.33	223	0.34
47	**100-year**	11.7	10.9	7.73	0.60	236	0.41
46	**2-year**	7.75	8.24	5.06	0.26	226	0.31
46	**100-year**	11.6	11.4	7.37	0.50	237	0.38
45.5	**Bridge**						
45	**2-year**	7.69	7.86	5.18	0.32	231	0.32
45	**100-year**	11.6	10.9	7.39	0.58	247	0.39
44	**2-year**	7.50	6.72	5.48	0.28	257	0.37
44	**100-year**	11.4	9.89	7.32	0.44	278	0.41
43	**2-year**	6.80	7.56	4.85	0.21	257	0.31
43	**100-year**	10.5	10.0	6.83	0.38	295	0.38
42	**2-year**	6.27	10.6	4.69	0.18	1300	0.25
42	**100-year**	9.35	13.0	7.81	0.46	1360	0.37
41.8	**2-year**	5.84	8.86	5.43	0.25	651	0.31
41.8	**100-year**	8.33	7.88	9.10	0.66	766	0.47
41.5	**2-year**	5.77	7.38	4.38	0.16	714	0.26
41.5	**100-year**	8.34	8.20	7.03	0.39	857	0.37
41.2	**2-year**	5.26	6.88	5.79	0.31	234	0.38
41.2	**100-year**	6.94	8.30	10.0	0.87	239	0.59
41	**2-year**	3.88	3.12	8.77	0.78	375	0.67
41	**100-year**	6.08	2.23	9.32	0.90	1300	0.73
40	**2-year**	3.51	2.88	5.90	0.39	683	0.51
40	**100-year**	4.85	3.68	8.12	0.69	806	0.64
39	**2-year**	2.42	1.84	8.79	0.99	717	0.96
39	**100-year**	3.69	2.56	9.92	1.18	922	0.98

Model Results – MHHW Boundary Condition

During high tide conditions the downstream portion of the Mendenhall River is under backwater conditions. As a result, the river is less influenced by the proposed fill under MHHW boundary conditions. Water surface elevation changes due to the proposed fill are at a maximum at the 100-year flow at cross-section 42. At this location the water surface rises by 0.2 feet (Table 4). A more complete table of model output results is included in Appendix D. Therefore, the proposed fill does not markedly influence the water surface elevation under MHHW conditions.

VIGIL AGRIMIS, INC.

tel: 503-274-2010
fax: 503-274-2024
email: lmark@vigil-agrimis.com

The proposed conditions cause an increase in channel velocities at the fill location at cross-sections 41.8 to 41.2. At these locations, channel velocities increase by 0.4 to 1.6 fps for a maximum velocity of 7.1 fps at cross-section 41.8 for the 100-year flood. Channel shear stresses also increase, but only by a relatively insubstantial 0.2 lbs/sq-ft. Froude numbers do not change substantially. Froude numbers are below 1.0 under MHHW conditions; therefore, the model indicates hydraulically stable conditions at high tides. Only nominal changes in water surface elevation, velocity, and shear stress occur above cross-section 41.8. No changes are indicated by the model downstream of cross-section 41.2.

Table 4a
Existing Conditions with MHHW Boundary Condition (11 ft-msl)

Cross-Section	Flow Conditions	W.S. Elevation (ft-msl)	Hydraulic Radius (ft)	Velocity Channel (ft/s)	Shear Channel (lb/sq ft)	Top Width (ft)	Froude # Channel
49	2-year	11.8	7.77	3.53	0.17	342	0.22
49	100-year	13.9	9.60	5.98	0.46	348	0.34
48	2-year	11.6	10.0	3.36	0.12	276	0.18
48	100-year	13.3	11.5	6.15	0.40	281	0.31
47	2-year	11.5	10.6	3.71	0.14	236	0.20
47	100-year	12.8	11.8	7.06	0.49	238	0.36
46	2-year	11.4	11.3	3.50	0.11	236	0.18
46	100-year	12.7	12.3	6.73	0.40	240	0.33
45.5	Bridge						
45	2-year	11.4	10.8	3.50	0.13	247	0.19
45	100-year	12.7	11.7	6.71	0.47	253	0.34
44	2-year	11.4	9.87	3.43	0.10	278	0.19
44	100-year	12.6	10.9	6.55	0.34	280	0.35
43	2-year	11.2	10.6	2.99	0.07	298	0.16
43	100-year	12.0	11.2	5.96	0.28	301	0.31
42	2-year	11.0	13.8	3.24	0.08	1400	0.15
42	100-year	11.2	13.9	6.87	0.35	1400	0.32
41.8	2-year	11.0	6.45	2.64	0.05	1220	0.12
41.8	100-year	11.1	6.51	5.60	0.23	1220	0.26
41.5	2-year	11.0	8.49	2.11	0.03	1610	0.10
41.5	100-year	11.1	8.53	4.49	0.15	1620	0.21
41.2	2-year	11.0	3.89	1.80	0.03	1860	0.10
41.2	100-year	11.0	3.89	3.85	0.12	1860	0.21
41	2-year	11.0	6.30	1.17	0.01	1650	0.07
41	100-year	11.0	6.32	2.49	0.05	1650	0.14
40	2-year	11.0	6.91	0.99	0.01	1740	0.06
40	100-year	11.0	6.91	2.11	0.04	1740	0.12
39	2-year	11.0	8.46	0.81	0.01	1420	0.05
39	100-year	11.0	8.46	1.73	0.03	1420	0.10

VIGIL AGRIMIS, INC.

tel: 503-274-2010
fax: 503-274-2024
email: lmark@vigil-agrimis.com

Table 4b
Proposed Conditions with MHHW Boundary Condition (11 ft-msl)

Cross-Section	Flow Conditions	W.S. Elevation (ft-msl)	Hydraulic Radius (ft)	Velocity Channel (ft/s)	Shear Channel (lb/sq ft)	Top Width (ft)	Froude # Channel
49	**2-year**	11.8	7.79	3.52	0.17	342	0.22
49	**100-year**	13.9	9.67	5.93	0.45	348	0.33
48	**2-year**	11.6	10.0	3.35	0.12	276	0.18
48	**100-year**	13.4	11.5	6.10	0.39	281	0.31
47	**2-year**	11.5	10.6	3.70	0.14	236	0.20
47	**100-year**	12.9	11.9	7.00	0.48	238	0.35
46	**2-year**	11.4	11.3	3.49	0.11	236	0.18
46	**100-year**	12.8	12.4	6.68	0.40	240	0.33
45.5	**Bridge**						
45	**2-year**	11.4	10.8	3.49	0.13	247	0.18
45	**100-year**	12.8	11.8	6.65	0.46	254	0.34
44	**2-year**	11.4	9.89	3.42	0.10	278	0.19
44	**100-year**	12.7	11.0	6.49	0.33	280	0.34
43	**2-year**	11.3	10.6	2.99	0.07	298	0.16
43	**100-year**	12.2	11.3	5.89	0.27	302	0.31
42	**2-year**	11.1	13.8	3.24	0.08	1400	0.15
42	**100-year**	11.3	14.0	6.79	0.34	1400	0.31
41.8	**2-year**	11.0	7.88	3.31	0.08	885	0.15
41.8	**100-year**	11.0	7.88	7.11	0.38	883	0.33
41.5	**2-year**	11.0	9.22	2.54	0.05	1410	0.12
41.5	**100-year**	11.0	9.22	5.43	0.22	1410	0.26
41.2	**2-year**	11.0	3.64	2.50	0.05	1580	0.12
41.2	**100-year**	10.9	3.55	5.45	0.23	1580	0.27
41	**2-year**	11.0	6.30	1.17	0.01	1650	0.07
41	**100-year**	11.0	6.32	2.49	0.05	1650	0.14
40	**2-year**	11.0	6.91	0.99	0.01	1740	0.06
40	**100-year**	11.0	6.91	2.11	0.04	1740	0.12
39	**2-year**	11.0	8.46	0.81	0.01	1420	0.05
39	**100-year**	11.0	8.46	1.73	0.03	1420	0.10

VIGIL AGRIMIS, INC.

tel: 503-274-2010
fax: 503-274-2024
email: lmark@vigil-agrimis.com

Conclusions

Additional analysis was performed by VAI on the Mendenhall River system at the west end of JNU. This analysis included:

- Locating the Mendenhall channel with GPS following the 2004 channel avulsion to confirm channel migration since that event,
- Modifying the existing USGS HEC-RAS model for the Mendenhall River to help assess proposed fill of wetlands adjacent to the runway as a wildlife hazard management strategy.

During the field assessment in November 2005 VAI staff mapped the location of the east bank of the Mendenhall River in the vicinity of JNU and the proposed fill. Active erosion and sediment deposition were observed immediately to the east of the meander cut off on the newly formed point. This is evidence that the channel is adjusting in response to the summer 2004 meander cut off/avulsion.

Planning-level information on hydraulic conditions was obtained using HEC-RAS hydraulic modeling software to determine the potential effects of the proposed fill on the hydraulics of the Mendenhall River near Juneau International Airport. Figures of the proposed fill extent for RSA 1, 5C, 6A, 6B, and 6C; WH-1b, WH-1c, WH-2b, and WH-2c that were used to develop the proposed conditions model are included in Appendix A for reference.

The HEC-RAS modeling indicates that the proposed fills won't have a large effect on the Mendenhall River under high tide conditions because these effects are dampened by tidally-caused backwater in the vicinity of the proposed fills under these conditions. Based on the modeling results, the influence of the fills under MHHW conditions is limited to a maximum of 0.2-feet increase in water-surface elevation and a maximum increase in channel velocity of 1.6 fps. The proposed conditions model, under both high and low tides, do not substantially change the Froude numbers, and therefore are not expected to significantly change the hydraulic stability from current conditions.

The HEC-RAS hydraulic modeling indicates that under low tide conditions, the proposed fills will likely cause minor changes in water surface elevation in the +/- 0.5-foot range near the proposed fills. However, this estimated increase in water surface elevation due to the proposed fill is minor compared to the increase in water surface elevation due to natural tidal conditions at the site. Channel velocities will increase by up to 2.4 fps near the proposed fills. Shear stress calculation indicates that cobble sized material will be mobilized during a 100-year event.

The dynamic nature of the Mendenhall River becomes evident when the modeling results are combined with field observations of erosion. The proposed filling the Mendenhall River floodplain/marshplain would create changes in the hydraulics and geomorphology of the river system that appear manageable. As mentioned earlier, this planning-level assessment is appropriate for impact assessment for the EIS; but a more detailed assessment will be desirable for project-level design and implementation. Bioengineering techniques would appear to be applicable for stabilization. While the changes in hydraulics and geomorphology appear manageable, special attention should be paid to the effects that the proposed fills will have on both the east and west banks of the Mendenhall River especially in the vicinity of the MALSR and along the dike adjacent to the Float Plane Pond.

VIGIL AGRIMIS, INC.

tel: 503-274-2010
fax: 503-274-2024
email: lmark@vigil-agrimis.com

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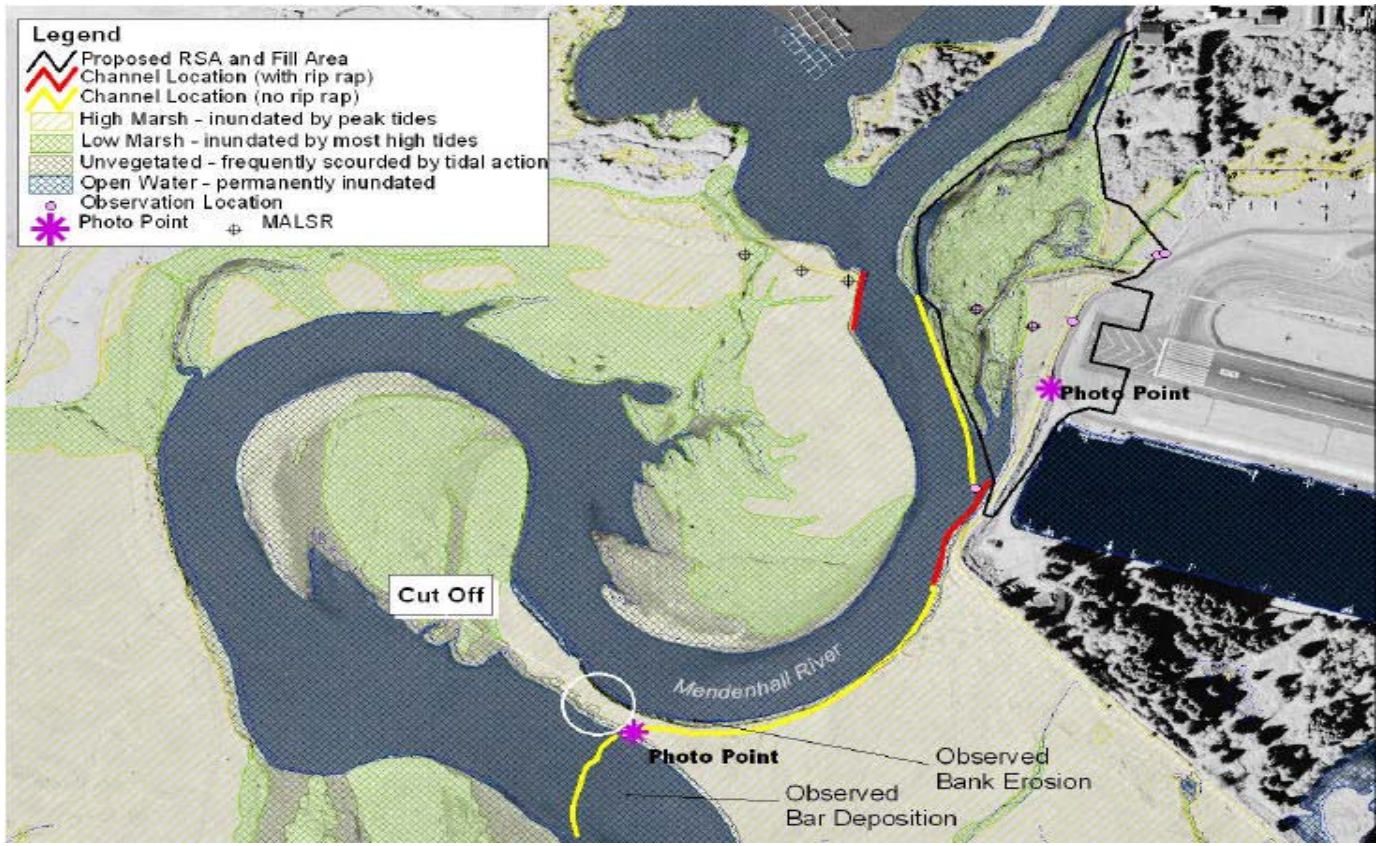
tel: 503-274-2010
fax: 503-274-2024
email: lmark@vigil-agrimis.com

Figure 1. Mendenhall River Field Assessment



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tel: 503-274-2010
fax: 503-274-2024
email: lmark@vigil-agrimis.com

Figure 2. Mendenhall River Meander Cutoff (~12:00 NOON November 9, 2005)

Note bar forming in the center of the image. The breach location is at the right.

Figure 3. Channel relocation looking northwest

Photo by Mike Knapp (ADOT)

Figure 4. Channel relocation looking southwest

Photo by Mike Knapp (ADOT)

819 SE Morrison Street, Suite 310
Portland, Oregon 97214

VIGIL AGRIMIS, INC.
tel: 503-274-2010
fax: 503-274-2024
email: lmark@vigil-agrimis.com

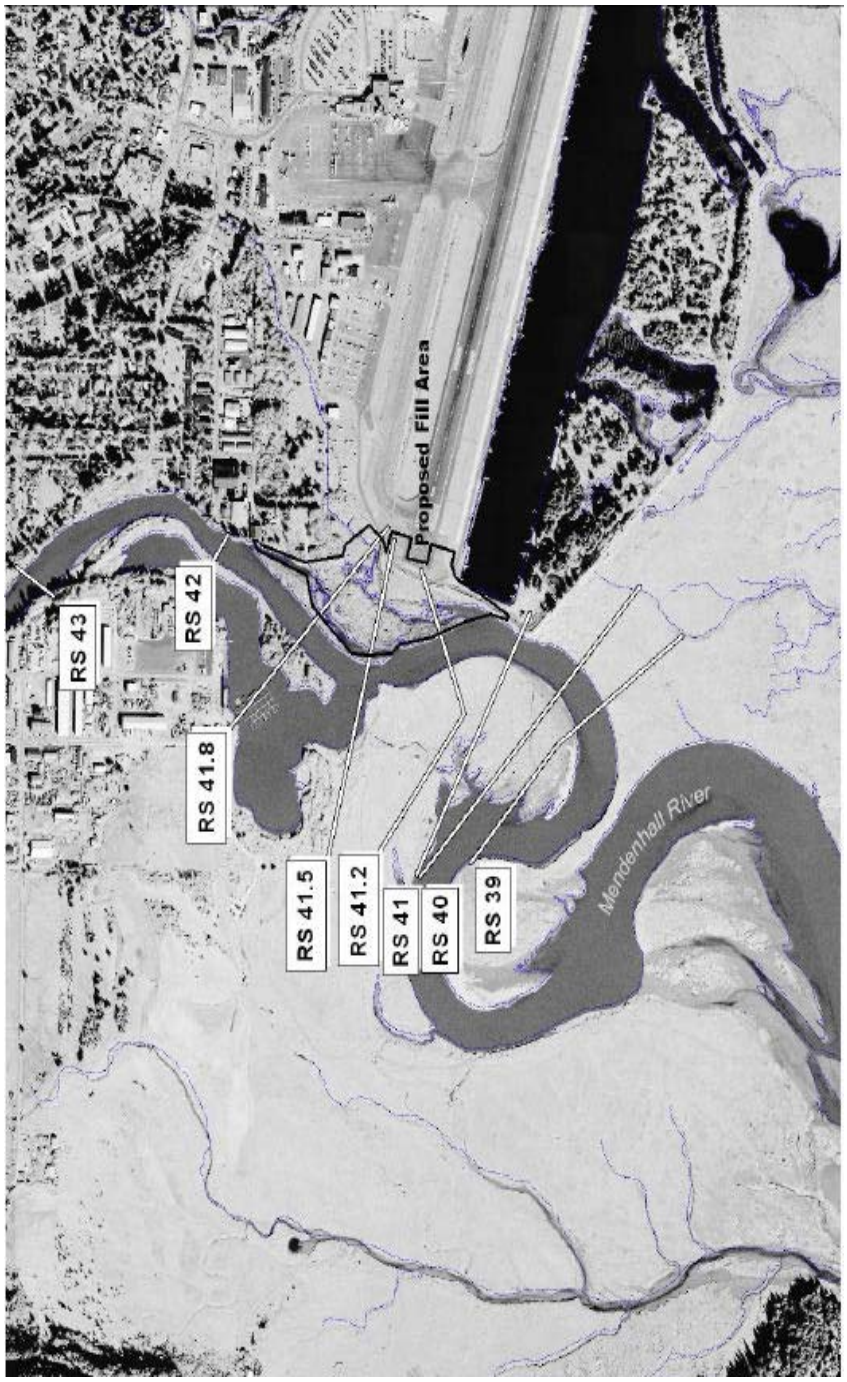
Figure 5. Channel breach location looking upstream.

Photo by Mike Knapp (ADOT)

Note the dike trail is visible in the upper right and the MALSR is visible along the top of the photo. Active erosion and deposition were observed around the point on center right of the photo.

VIGIL AGRIMIS, INC
tel: 503-274-201
fax: 503-274-202
email: lmark@vigil-agrimis.com

Figure 6. HEC-RAS Cross-Section Locations



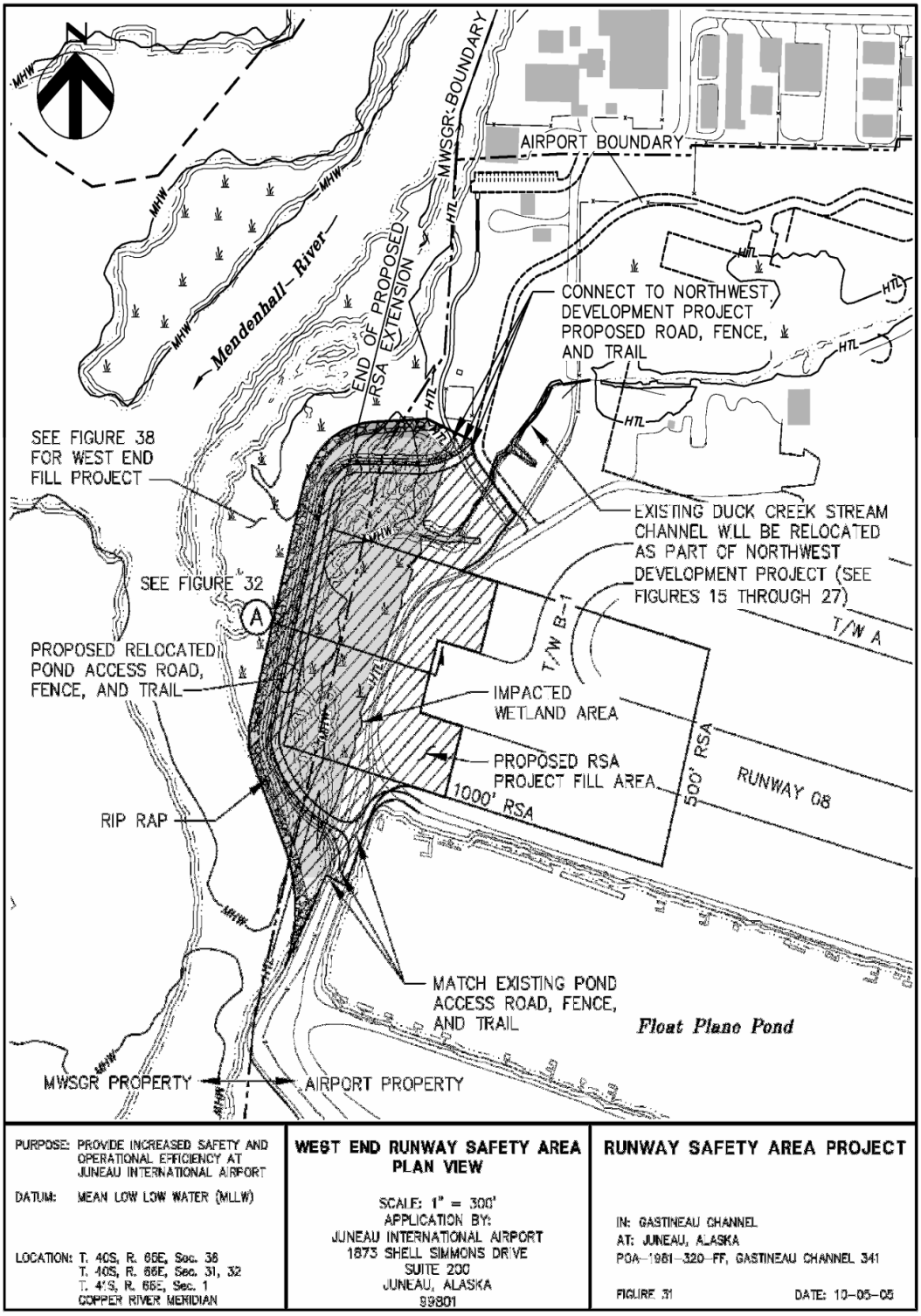
819 SE Morrison Street, Suite 31
Portland, Oregon 9721

VIGL AGRIMIS, INC.

tel: 503-274-2010
fax: 503-274-2024
email: lmark@vigil-agrimis.com

Appendix A.
Section 404 permit application Figures 31, 32, 38, and 39 (HDR, 2005)

VIGIL AGRIMIS, INC.
tel: 503-274-2010
fax: 503-274-2024
email: lmark@vigil-agrimis.com



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Portland, Oregon 97214

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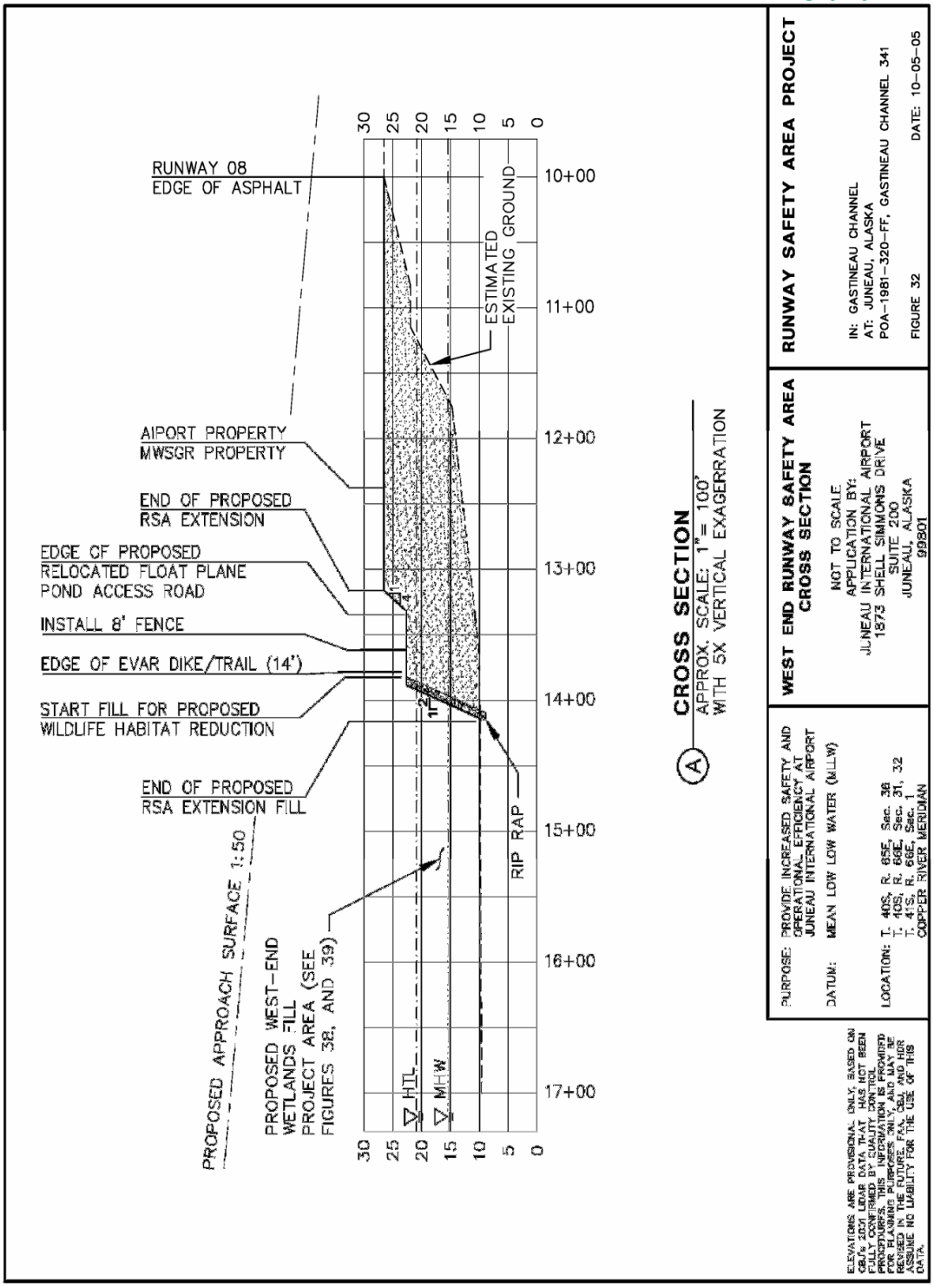
tel: 503-274-2010
fax: 503-274-2024
email: lmark@vigil-agrimis.com



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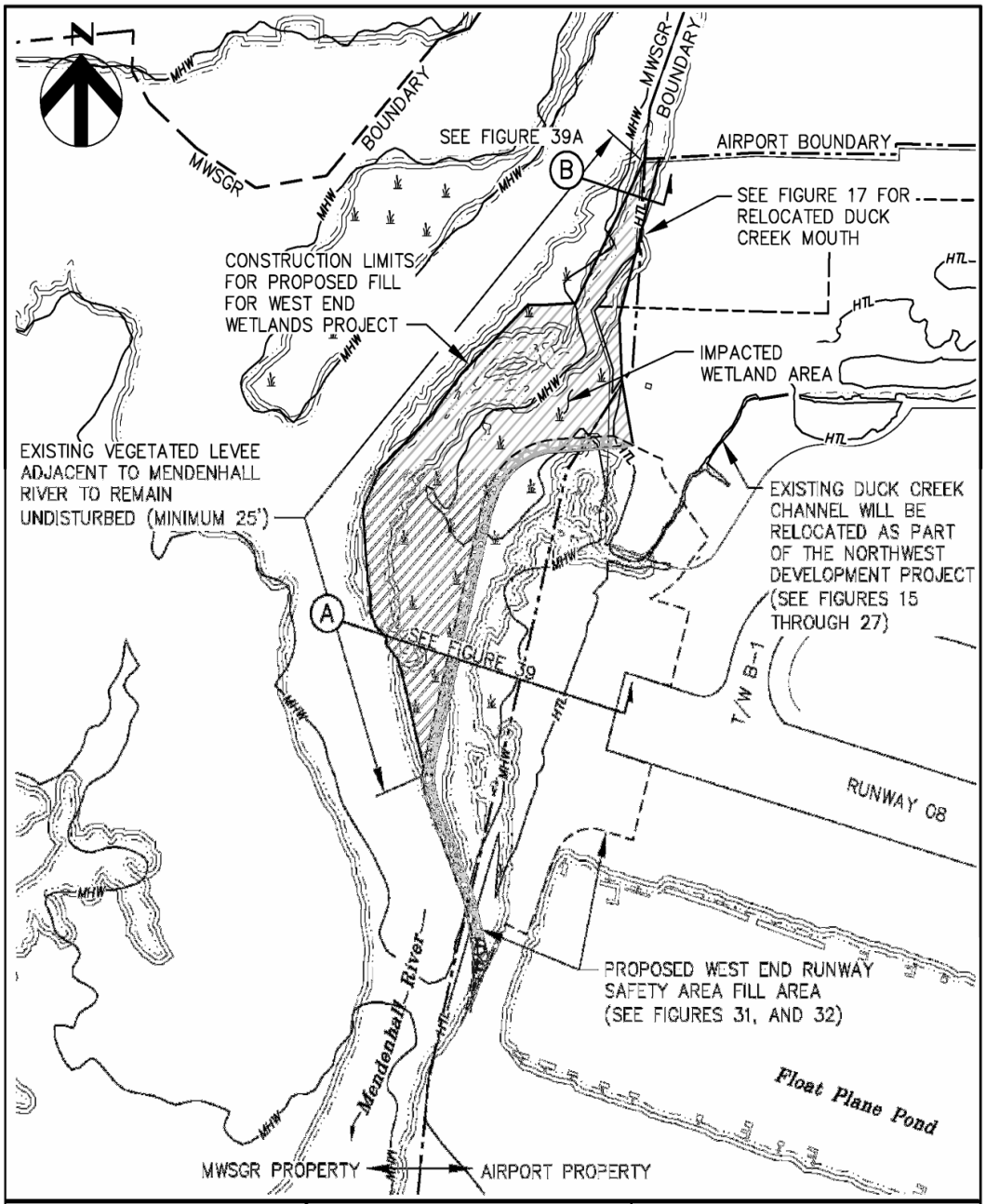
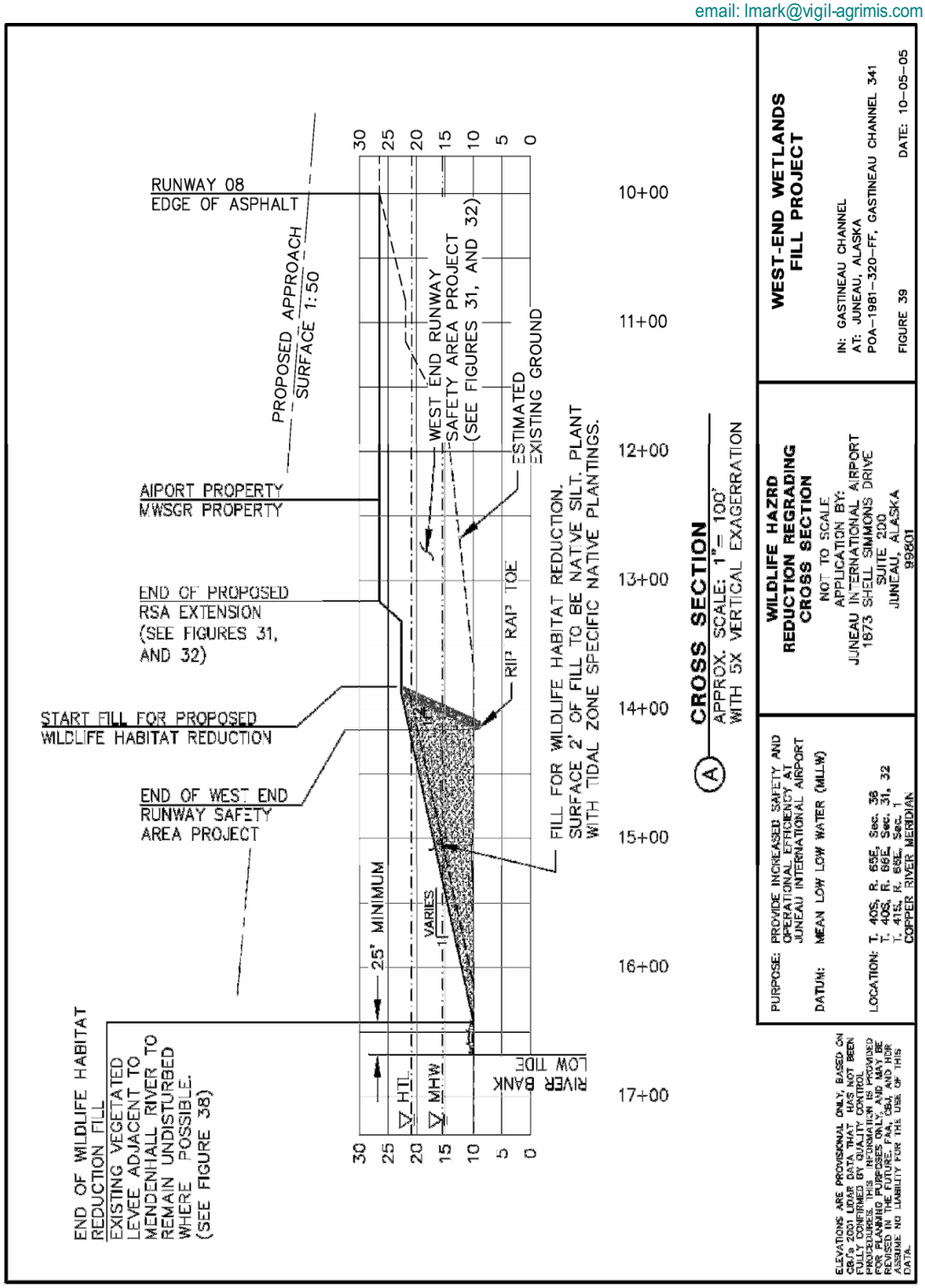
fax: 503-274-2024
email: lmark@vigil-agrimis.com



PURPOSE: PROVIDE INCREASED SAFETY AT JUNEAU INTERNATIONAL AIRPORT DATUM: MEAN LOW LOW WATER (MLLW) LOCATION: T. 40S, R. 65E, Sec. 36 COPPER RIVER MERIDIAN	**WILDLIFE HAZARD REDUCTION REGRADING PLAN VIEW** SCALE: 1" = 400' APPLICATION BY: JUNEAU INTERNATIONAL AIRPORT 1873 SHELL SIMMONS DRIVE SUITE 200 JUNEAU, ALASKA 99801	**WEST-END WETLANDS FILL PROJECT** IN: GASTINEAU CHANNEL AT: JUNEAU, ALASKA POA-1981-320-FF, GASTINEAU CHANNEL 341 FIGURE 38 OF DATE: 10-05-05

VIGL AGRIMIS, INC.

tel: 503-274-2010
fax: 503-274-2024
email: lmark@vigil-agrimis.com



819 SE Morrison Street, Suite 310
Portland, Oregon 97214

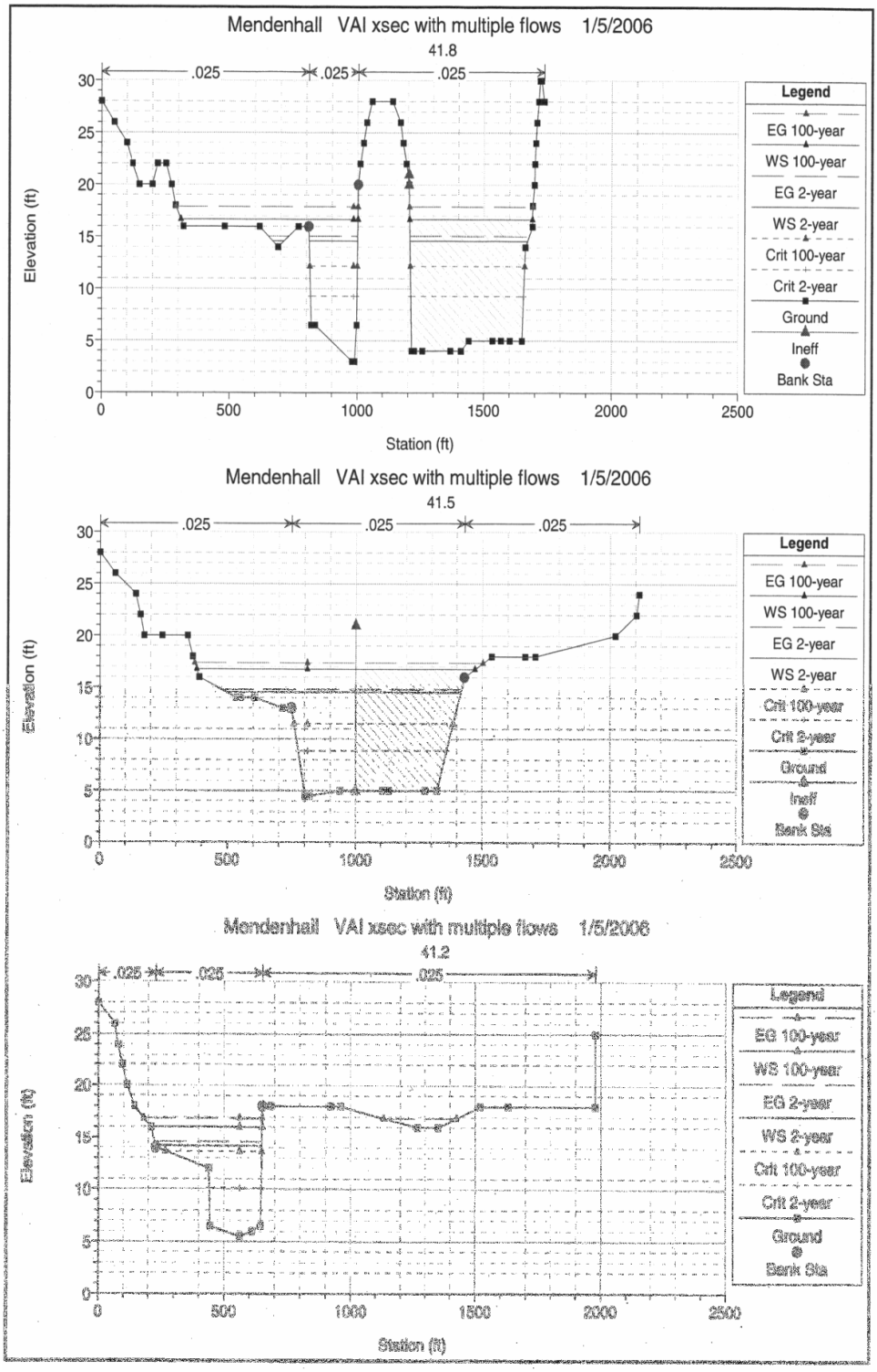
VIGIL AGRIMIS, INC.

tel: 503-274-2010
fax: 503-274-2024
email: lmark@vigil-agrimis.com

Appendix B.
Existing conditions cross-section in the vicinity of the proposed changes, shown with MLLW (-4.4 foot-mllw) water-surface elevation boundary condition

VIGIL AGRIMIS, INC.

tel: 503-274-2010
fax: 503-274-2024
email: lmark@vigil-agrimis.com



819 SE Morrison Street, Suite 310
Portland, Oregon 97214

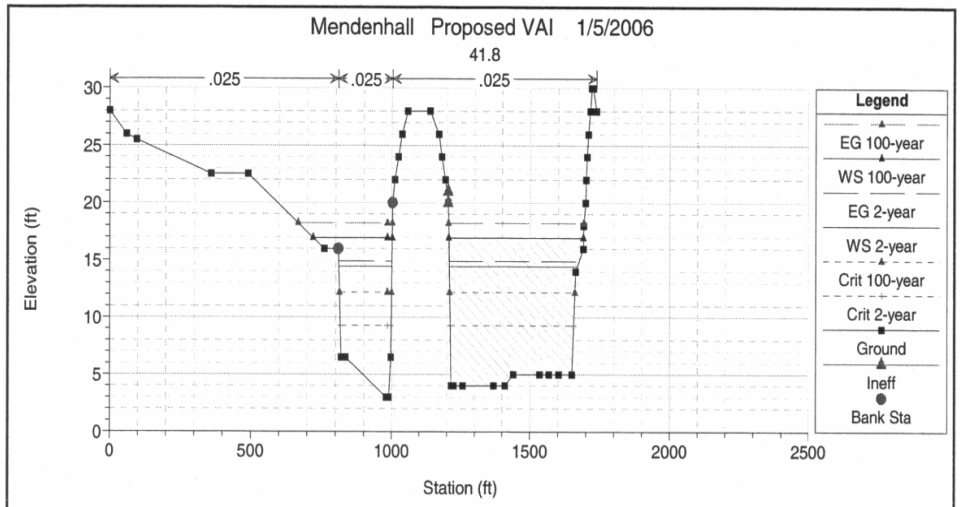
VIGIL AGRIMIS, INC.

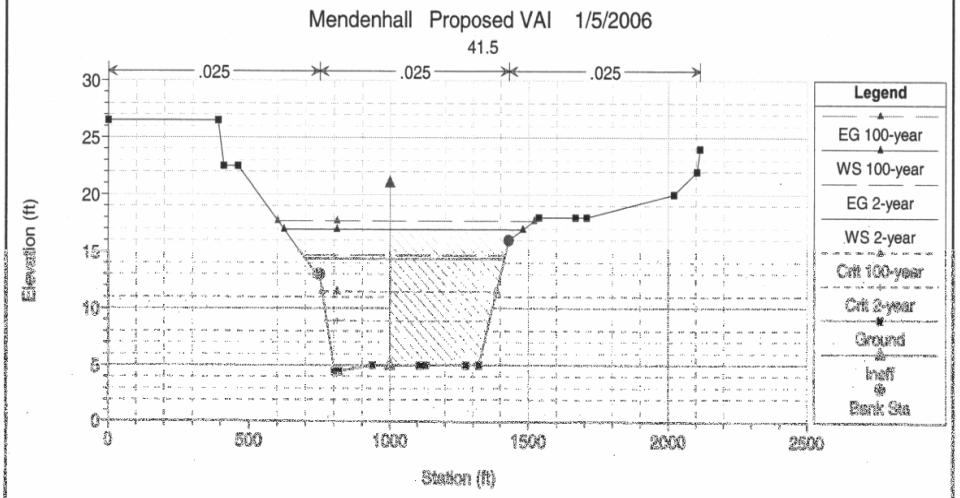
tel: 503-274-2010
fax: 503-274-2024
email: lmark@vigil-agrimis.com

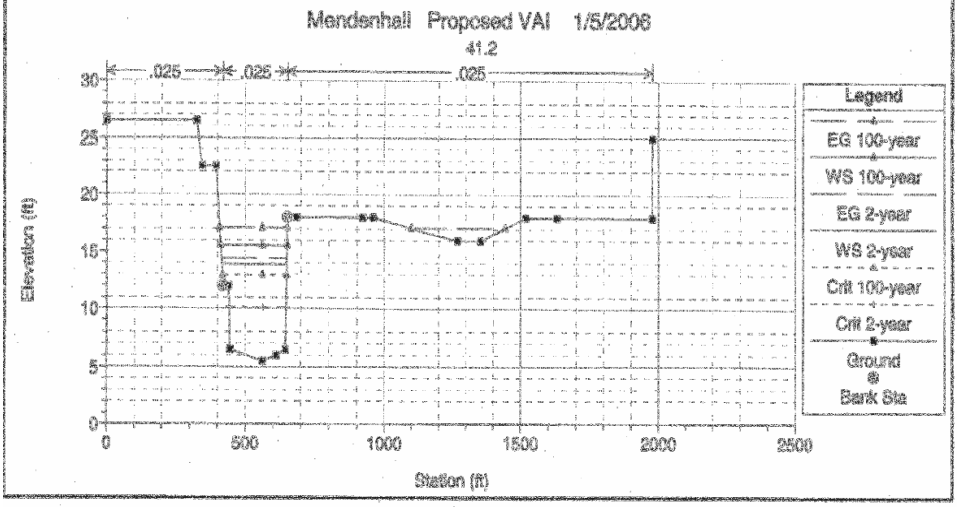
Appendix C.
Proposed conditions cross-sections in the vicinity of the proposed changes, shown with MLLW (-4.4 foot-mllw) water-surface elevation boundary condition

VIGIL AGRIMIS, INC.

tel: 503-274-2010
fax: 503-274-2024
email: lmark@vigil-agrimis.com







819 SE Morrison Street, Suite 310
Portland, Oregon 97214

VIGIL AGRIMIS, INC.

tel: 503-274-2010
fax: 503-274-2024
email: lmark@vigil-agrimis.com

Appendix D.
HEC-RAS model output for MLLW and MHHW Boundary Conditions

VIGIL AGRIMIS, INC.

tel: 503-274-2010
fax: 503-274-2024
email: lmark@vigil-agrimis.com

Existing Conditions Model With Downstream Boundary Condition = 19.6 feet-mllw

Cross-Section	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Hydr Radius (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Vel Left (ft/s)	Vel Right (ft/s)	Shear Chan (lb/sq ft)	Shear Total (lb/sq ft)	Flow Area (sq ft)	Top Width (ft)	Froude # Ch
49	2-year	6.04	20.4	7.77	12.7	20.6	0.000353	3.53			0.17	0.17	2710	342	0.22
49	10-year	6.04	21.2	8.50	14.1	21.6	0.000579	4.80			0.31	0.31	2990	344	0.29
49	25-year	6.04	21.7	8.91	14.7	22.1	0.000665	5.31			0.37	0.37	3150	346	0.31
49	50-year	6.04	22.1	9.26	15.2	22.6	0.000720	5.67			0.42	0.42	3290	347	0.32
49	100-year	6.04	22.5	9.60	15.7	23.0	0.000762	5.98			0.46	0.46	3430	348	0.34
48	2-year	1.06	20.2	10.0	10.5	20.4	0.000200	3.36			0.12	0.12	2850	276	0.18
48	10-year	1.06	20.9	10.6	12.6	21.2	0.000369	4.74			0.24	0.24	3030	278	0.25
48	25-year	1.06	21.3	10.9	13.4	21.7	0.000448	5.33			0.30	0.30	3140	279	0.28
48	50-year	1.06	21.6	11.2	14.0	22.1	0.000507	5.76			0.35	0.35	3240	280	0.30
48	100-year	1.06	21.9	11.5	14.5	22.5	0.000557	6.15			0.40	0.40	3330	281	0.31
47	2-year	2.55	20.1	10.6	11.4	20.3	0.000210	3.71			0.14	0.14	2580	236	0.20
47	10-year	2.55	20.6	11.1	12.8	21.0	0.000408	5.32			0.28	0.28	2700	236	0.28
47	25-year	2.55	20.9	11.3	13.5	21.4	0.000510	6.04			0.36	0.36	2770	237	0.31
47	50-year	2.55	21.1	11.5	14.0	21.8	0.000589	6.58			0.42	0.42	2840	237	0.34
47	100-year	2.55	21.4	11.8	14.5	22.2	0.000661	7.06			0.49	0.49	2900	238	0.36
46	2-year	4.94	20.0	11.3	11.4	20.2	0.000159	3.50			0.11	0.11	2740	236	0.18
46	10-year	4.94	20.5	11.7	12.8	20.9	0.000316	5.04			0.23	0.23	2850	237	0.26
46	25-year	4.94	20.8	11.9	13.3	21.3	0.000399	5.74			0.30	0.30	2920	238	0.29
46	50-year	4.94	21.0	12.1	13.8	21.6	0.000465	6.26			0.35	0.35	2980	239	0.31
46	100-year	4.94	21.3	12.3	14.2	22.0	0.000526	6.73			0.40	0.40	3040	240	0.33
45.5	Bridge														
45	2-year	4.21	20.0	10.8	11.7	20.2	0.000195	3.50			0.13	0.13	2740	247	0.19
45	10-year	4.21	20.5	11.2	13.0	20.9	0.000387	5.03			0.27	0.27	2850	249	0.26
45	25-year	4.21	20.8	11.4	13.6	21.3	0.000488	5.73			0.35	0.35	2930	250	0.30
45	50-year	4.21	21.0	11.6	14.0	21.6	0.000569	6.25			0.41	0.41	2990	252	0.32
45	100-year	4.21	21.3	11.7	14.4	22.0	0.000645	6.71			0.47	0.47	3050	253	0.34
44	2-year	7.69	20.0	9.87	12.5	20.2	0.000157	3.43			0.10	0.10	2790	278	0.19
44	10-year	7.69	20.4	10.3	13.8	20.8	0.000308	4.93			0.20	0.20	2920	278	0.27
44	25-year	7.69	20.7	10.5	14.3	21.2	0.000386	5.60			0.25	0.25	2990	279	0.30
44	50-year	7.69	20.9	10.7	14.7	21.5	0.000447	6.10			0.30	0.30	3060	279	0.33
44	100-year	7.69	21.2	10.9	15.1	21.8	0.000502	6.55			0.34	0.34	3130	280	0.35
43	2-year	4.65	19.8	10.6	10.7	20.0	0.000110	2.99			0.07	0.07	3200	298	0.16
43	10-year	4.65	20.1	10.8	12.0	20.4	0.000228	4.38			0.15	0.15	3280	299	0.23
43	25-year	4.65	20.3	10.9	12.5	20.7	0.000295	5.02			0.20	0.20	3340	300	0.27
43	50-year	4.65	20.5	11.1	13.0	20.9	0.000349	5.51			0.24	0.24	3390	300	0.29
43	100-year	4.65	20.6	11.2	13.4	21.2	0.000402	5.96			0.28	0.28	3440	301	0.31
42	2-year	0.83	19.6	13.8	7.77	19.8	0.0000900	3.24			0.08	0.08	2960	1400	0.15
42	10-year	0.83	19.7	13.8	9.27	20.1	0.000201	4.85			0.17	0.17	2960	1400	0.22
42	25-year	0.83	19.7	13.8	9.94	20.2	0.000271	5.64			0.23	0.23	2970	1400	0.26
42	50-year	0.83	19.8	13.9	10.5	20.4	0.000334	6.27			0.29	0.29	2980	1400	0.29
42	100-year	0.83	19.8	13.9	10.9	20.5	0.000400	6.87			0.35	0.35	2980	1400	0.32
41.8	2-year	3.00	19.6	6.45	9.28	19.7	0.0000820	2.64	1.14		0.05	0.03	4770	1220	0.12
41.8	10-year	3.00	19.6	6.47	10.6	19.8	0.000139	3.95	1.71		0.12	0.06	4790	1220	0.18
41.8	25-year	3.00	19.7	6.48	11.3	19.9	0.000189	4.60	1.99		0.16	0.08	4800	1220	0.21
41.8	50-year	3.00	19.7	6.50	11.8	20.0	0.000233	5.11	2.22		0.19	0.09	4800	1220	0.24
41.8	100-year	3.00	19.7	6.51	12.2	20.1	0.000279	5.60	2.43		0.23	0.11	4810	1220	0.26
41.5	2-year	4.50	19.6	8.49	8.86	19.7	0.0000380	2.11	1.08		0.03	0.02	5540	1610	0.10
41.5	10-year	4.50	19.6	8.51	10.1	19.8	0.0000840	3.16	1.62		0.07	0.04	5550	1610	0.15
41.5	25-year	4.50	19.6	8.52	10.7	19.8	0.000114	3.68	1.89		0.10	0.06	5560	1620	0.17
41.5	50-year	4.50	19.7	8.53	11.1	19.9	0.000141	4.09	2.10		0.12	0.08	5560	1620	0.19
41.5	100-year	4.50	19.7	8.53	11.5	19.9	0.000169	4.49	2.30		0.15	0.09	5570	1620	0.21
41.2	2-year	5.50	19.6	3.89	10.1	19.6	0.0000440	1.80	0.74	0.64	0.03	0.01	7260	1880	0.10
41.2	10-year	5.50	19.6	3.89	11.4	19.7	0.0000990	2.70	1.10	0.96	0.06	0.02	7260	1880	0.15
41.2	25-year	5.50	19.6	3.89	12.0	19.7	0.000134	3.15	1.29	1.13	0.08	0.03	7260	1880	0.18
41.2	50-year	5.50	19.6	3.89	13.1	19.8	0.000167	3.51	1.43	1.25	0.10	0.04	7270	1880	0.20
41.2	100-year	5.50	19.6	3.89	13.6	19.8	0.000200	3.85	1.57	1.38	0.12	0.05	7270	1880	0.21
41	2-year	5.91	19.6	6.30	11.2	19.6	0.0000190	1.17		0.80	0.01	0.01	10400	1650	0.07
41	10-year	5.91	19.6	6.31	13.6	19.7	0.0000420	1.75		1.19	0.03	0.02	10500	1650	0.10
41	25-year	5.91	19.6	6.31	14.3	19.7	0.0000580	2.04		1.39	0.03	0.02	10500	1650	0.12
41	50-year	5.91	19.6	6.32	14.5	19.7	0.0000710	2.27		1.55	0.04	0.03	10500	1650	0.13
41	100-year	5.91	19.6	6.32	14.7	19.7	0.0000860	2.49		1.70	0.05	0.03	10500	1650	0.14
40	2-year	6.00	19.6	6.91	11.0	19.6	0.0000130	0.99		0.74	0.01	0.01	12100	1740	0.06
40	10-year	6.00	19.6	6.91	11.7	19.6	0.0000290	1.48		1.11	0.02	0.01	12100	1740	0.08
40	25-year	6.00	19.6	6.91	12.0	19.6	0.0000400	1.73		1.29	0.02	0.02	12100	1740	0.10
40	50-year	6.00	19.6	6.91	12.2	19.7	0.0000490	1.92		1.44	0.03	0.02	12100	1740	0.11
40	100-year	6.00	19.6	6.91	12.4	19.7	0.0000600	2.11		1.58	0.04	0.03	12100	1740	0.12
39	2-year	7.00	19.6	8.46	11.0	19.6	0.0000100	0.81		0.79	0.01	0.01	12100	1420	0.05
39	10-year	7.00	19.6	8.46	11.6	19.6	0.0000230	1.21		1.18	0.01	0.01	12100	1420	0.07
39	25-year	7.00	19.6	8.46	11.9	19.6	0.0000320	1.41		1.37	0.02	0.02	12100	1420	0.08
39	50-year	7.00	19.6	8.46	12.1	19.6	0.0000390	1.57		1.53	0.02	0.02	12100	1420	0.09
39	100-year	7.00	19.6	8.46	12.3	19.6	0.0000470	1.73		1.68	0.03	0.02	12100	1420	0.10

819 SE Morrison Street, Suite 310
Portland, Oregon 97214

VIGIL AGRIMIS, INC.

tel: 503-274-2010
fax: 503-274-2024
email: lmark@vigil-agrimis.com

Proposed Conditions Model With Downstream Boundary Condition = 19.6 feet-mllw

Cross-Section	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Hydr Radius (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Vel Left (ft/s)	Vel Right (ft/s)	Shear Chan (lb/sq ft)	Shear Total (lb/sq ft)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
49	2-year	6.04	20.4	7.79	12.7	20.6	0.000350	3.52			0.17	0.17	2720	342	0.22
49	10-year	6.04	21.3	8.54	14.1	21.6	0.000569	4.78			0.30	0.30	3010	344	0.28
49	25-year	6.04	21.7	8.96	14.7	22.2	0.000652	5.28			0.36	0.36	3170	346	0.31
49	50-year	6.04	22.1	9.32	15.2	22.6	0.000704	5.63			0.41	0.41	3310	347	0.32
49	100-year	6.04	22.5	9.67	15.7	23.1	0.000743	5.93			0.45	0.45	3450	348	0.33
48	2-year	1.06	20.2	10.0	10.5	20.4	0.000199	3.35			0.12	0.12	2860	276	0.18
48	10-year	1.06	20.9	10.6	12.6	21.3	0.000364	4.71			0.24	0.24	3050	278	0.25
48	25-year	1.06	21.3	10.9	13.4	21.8	0.000440	5.30			0.30	0.30	3160	279	0.28
48	50-year	1.06	21.7	11.2	14.0	22.2	0.000496	5.72			0.35	0.35	32600	280	0.30
48	100-year	1.06	22.0	11.5	14.5	22.6	0.000544	6.10			0.39	0.39	3360	281	0.31
47	2-year	2.55	20.1	10.6	11.4	20.3	0.000208	3.70			0.14	0.14	2590	236	0.20
47	10-year	2.55	20.6	11.1	12.8	21.1	0.000402	5.29			0.28	0.28	2710	236	0.28
47	25-year	2.55	20.9	11.4	13.5	21.5	0.000501	6.00			0.36	0.36	2790	237	0.31
47	50-year	2.55	21.2	11.6	14.0	21.9	0.000576	6.53			0.42	0.42	2860	237	0.33
47	100-year	2.55	21.5	11.9	14.5	22.3	0.000644	7.00			0.48	0.48	2930	238	0.35
46	2-year	4.94	20.0	11.3	11.4	20.2	0.000158	3.49			0.11	0.11	2740	236	0.18
46	10-year	4.94	20.6	11.7	12.8	20.9	0.000312	5.02			0.23	0.23	2860	238	0.25
46	25-year	4.94	20.9	12.0	13.3	21.4	0.000392	5.71			0.29	0.29	2940	238	0.29
46	50-year	4.94	21.1	12.2	13.8	21.7	0.000455	6.22			0.35	0.35	3000	239	0.31
46	100-year	4.94	21.4	12.4	14.2	22.1	0.000512	6.68			0.40	0.40	3070	240	0.33
45.5	Bridge														
45	2-year	4.21	20.0	10.8	11.7	20.2	0.000194	3.49			0.13	0.13	2740	247	0.18
45	10-year	4.21	20.5	11.2	13.0	20.9	0.000381	5.01			0.27	0.27	2870	249	0.26
45	25-year	4.21	20.8	11.4	13.6	21.4	0.000480	5.69			0.34	0.34	2940	251	0.29
45	50-year	4.21	21.1	11.6	14.0	21.7	0.000557	6.20			0.40	0.40	3010	252	0.32
45	100-year	4.21	21.4	11.8	14.4	22.1	0.000629	6.65			0.46	0.46	3080	254	0.34
44	2-year	7.69	20.0	9.89	12.5	20.2	0.000156	3.42			0.10	0.10	2800	278	0.19
44	10-year	7.69	20.5	10.3	13.8	20.9	0.000303	4.90			0.20	0.20	2930	279	0.27
44	25-year	7.69	20.8	10.6	14.3	21.3	0.000378	5.56			0.25	0.25	3010	279	0.30
44	50-year	7.69	21.0	10.8	14.7	21.6	0.000435	6.05			0.29	0.29	3080	280	0.32
44	100-year	7.69	21.3	11.0	15.1	21.9	0.000486	6.49			0.33	0.33	3160	280	0.34
43	2-year	4.65	19.9	10.6	10.7	20.0	0.000109	2.99			0.07	0.07	3210	298	0.16
43	10-year	4.65	20.2	10.8	12.0	20.5	0.000224	4.35			0.15	0.15	3300	299	0.23
43	25-year	4.65	20.4	11.0	12.5	20.8	0.000288	4.98			0.20	0.20	3370	300	0.26
43	50-year	4.65	20.6	11.1	13.0	21.0	0.000339	5.46			0.24	0.24	3420	301	0.29
43	100-year	4.65	20.8	11.3	13.4	21.3	0.000387	5.89			0.27	0.27	3480	302	0.31
42	2-year	0.83	19.7	13.8	7.77	19.8	0.0000900	3.24			0.08	0.08	2960	1400	0.15
42	10-year	0.83	19.8	13.9	9.27	20.1	0.000198	4.82			0.17	0.17	2980	1400	0.22
42	25-year	0.83	19.8	13.9	9.94	20.3	0.000266	5.60			0.23	0.23	2990	1400	0.26
42	50-year	0.83	19.9	14.0	10.5	20.5	0.000325	6.22			0.28	0.28	3000	1400	0.28
42	100-year	0.83	19.9	14.0	10.9	20.7	0.000386	6.79			0.34	0.34	3020	1400	0.31
41.8	2-year	3.00	19.6	7.88	9.28	19.8	0.0000990	3.31	1.01		0.08	0.05	3200	885	0.15
41.8	10-year	3.00	19.6	7.88	10.6	19.9	0.000223	4.98	1.52		0.18	0.11	3200	885	0.23
41.8	25-year	3.00	19.6	7.88	11.3	20.1	0.000304	5.81	1.77		0.25	0.15	3190	884	0.27
41.8	50-year	3.00	19.6	7.88	11.8	20.2	0.000377	6.47	1.97		0.31	0.19	3190	884	0.30
41.8	100-year	3.00	19.6	7.88	12.2	20.3	0.000455	7.11	2.16		0.38	0.22	3190	883	0.33
41.5	2-year	4.50	19.6	9.22	8.86	19.7	0.000055	2.54	1.00		0.05	0.03	4200	1410	0.12
41.5	10-year	4.50	19.6	9.22	10.1	19.8	0.000123	3.81	1.51		0.11	0.07	4200	1410	0.18
41.5	25-year	4.50	19.6	9.22	10.7	19.9	0.000167	4.45	1.76		0.15	0.10	4200	1410	0.21
41.5	50-year	4.50	19.6	9.22	11.1	20.0	0.000207	4.95	1.96		0.18	0.12	4200	1410	0.23
41.5	100-year	4.50	19.6	9.22	11.5	20.0	0.000249	5.43	2.15		0.22	0.14	4200	1410	0.26
41.2	2-year	5.50	19.6	3.64	10.1	19.7	0.000062	2.50	1.06	0.76	0.05	0.01	5780	1580	0.12
41.2	10-year	5.50	19.6	3.61	11.4	19.7	0.000142	3.77	1.63	1.14	0.11	0.03	5730	1580	0.19
41.2	25-year	5.50	19.5	3.59	12.1	19.8	0.000195	4.42	1.90	1.32	0.15	0.04	5700	1580	0.22
41.2	50-year	5.50	19.5	3.57	12.6	19.8	0.000244	4.94	2.13	1.47	0.19	0.05	5670	1580	0.24
41.2	100-year	5.50	19.5	3.55	12.9	19.9	0.000298	5.45	2.34	1.61	0.23	0.07	5640	1580	0.27
41	2-year	5.91	19.6	6.30	11.2	19.6	0.0000190	1.17		0.80	0.01	0.01	10400	1650	0.07
41	10-year	5.91	19.6	6.31	13.6	19.7	0.0000420	1.75		1.19	0.03	0.02	10500	1650	0.10
41	25-year	5.91	19.6	6.31	14.3	19.7	0.0000580	2.04		1.39	0.03	0.02	10500	1650	0.12
41	50-year	5.91	19.6	6.32	14.5	19.7	0.0000710	2.27		1.55	0.04	0.03	10500	1650	0.13
41	100-year	5.91	19.6	6.32	14.7	19.7	0.0000880	2.49		1.70	0.05	0.03	10500	1650	0.14
40	2-year	6.00	19.6	6.91	11.0	19.6	0.0000130	0.99		0.74	0.01	0.01	12100	1740	0.06
40	10-year	6.00	19.6	6.91	11.7	19.6	0.0000290	1.48		1.11	0.02	0.01	12100	1740	0.08
40	25-year	6.00	19.6	6.91	12.0	19.6	0.0000400	1.73		1.29	0.02	0.02	12100	1740	0.10
40	50-year	6.00	19.6	6.91	12.2	19.7	0.0000490	1.92		1.44	0.03	0.02	12100	1740	0.11
40	100-year	6.00	19.6	6.91	12.4	19.7	0.0000600	2.11		1.58	0.04	0.03	12100	1740	0.12
39	2-year	7.00	19.6	8.46	11.0	19.6	0.0000100	0.81		0.79	0.01	0.01	12100	1420	0.05
39	10-year	7.00	19.6	8.46	11.6	19.6	0.0000230	1.21		1.18	0.01	0.01	12100	1420	0.07
39	25-year	7.00	19.6	8.46	11.9	19.6	0.0000320	1.41		1.37	0.02	0.02	12100	1420	0.08
39	50-year	7.00	19.6	8.46	12.1	19.6	0.0000390	1.57		1.53	0.02	0.02	12100	1420	0.09
39	100-year	7.00	19.6	8.46	12.3	19.6	0.0000470	1.73		1.68	0.03	0.02	12100	1420	0.10

819 SE Morrison Street, Suite 310
Portland, Oregon 97214

VIGIL AGRIMIS, INC.

tel: 503-274-2010
fax: 503-274-2024
email: lmark@vigil-agrimis.com

Existing Conditions Model With Downstream Boundary Condition = -4.4 feet-mllw

Cross-Section	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Hydr Radius (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Vel Left (ft/s)	Vel Right (ft/s)	Shear Chan (lb/sq ft)	Shear Total (lb/sq ft)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
49	2-year	6.04	17.4	6.68	12.7	17.9	0.00104	5.48			0.43	0.43	1750	256	0.37
49	10-year	6.04	19.5	7.01	14.1	20.1	0.00114	5.93			0.50	0.50	2420	339	0.39
49	25-year	6.04	20.4	7.78	14.7	21.0	0.00108	6.17			0.52	0.52	2710	342	0.39
49	50-year	6.04	21.0	8.32	15.2	21.6	0.00105	6.38			0.55	0.55	2920	344	0.39
49	100-year	6.04	21.6	8.82	15.7	22.2	0.00103	6.56			0.57	0.57	3120	345	0.38
48	2-year	1.06	17.0	8.09	10.5	17.3	0.000531	4.76			0.27	0.27	2010	242	0.29
48	10-year	1.06	18.9	9.10	12.6	19.4	0.000662	5.75			0.38	0.38	2500	267	0.33
48	25-year	1.06	19.8	9.64	13.4	20.3	0.000703	6.15			0.42	0.42	2720	274	0.34
48	50-year	1.06	20.3	10.1	14.0	21.0	0.000729	6.47			0.46	0.46	2890	277	0.35
48	100-year	1.06	20.9	10.6	14.5	21.6	0.000748	6.75			0.49	0.49	3040	278	0.36
47	2-year	2.55	16.5	7.78	11.4	17.0	0.000675	5.41			0.33	0.33	1770	223	0.34
47	10-year	2.55	18.4	9.13	12.8	19.0	0.000806	6.58			0.46	0.46	2180	233	0.38
47	25-year	2.55	19.1	9.81	13.5	19.9	0.000851	7.09			0.52	0.52	2360	234	0.39
47	50-year	2.55	19.7	10.3	14.0	20.5	0.000896	7.50			0.57	0.57	2490	235	0.41
47	100-year	2.55	20.1	10.7	14.5	21.1	0.000932	7.87			0.62	0.62	2600	236	0.42
46	2-year	4.94	16.4	8.30	11.4	16.8	0.000495	5.02			0.26	0.26	1910	226	0.30
46	10-year	4.94	18.2	9.81	12.8	18.8	0.000604	6.20			0.37	0.37	2320	231	0.34
46	25-year	4.94	19.0	10.4	13.3	19.7	0.000653	6.72			0.43	0.43	2490	233	0.36
46	50-year	4.94	19.5	10.9	13.8	20.3	0.000698	7.14			0.47	0.47	2620	235	0.38
46	100-year	4.94	20.0	11.3	14.2	20.9	0.000735	7.50			0.52	0.52	27300	236	0.39
45.5	Bridge														
45	2-year	4.21	16.4	7.92	11.7	16.8	0.000634	5.13			0.31	0.31	1870	232	0.32
45	10-year	4.21	18.2	9.42	13.0	18.8	0.000749	6.26			0.44	0.44	2300	238	0.36
45	25-year	4.21	19.0	10.0	13.6	19.7	0.000809	6.77			0.51	0.51	2500	242	0.37
45	50-year	4.21	19.5	10.4	14.0	20.3	0.000863	7.17			0.56	0.56	2600	244	0.39
45	100-year	4.21	20.0	10.8	14.4	20.8	0.000907	7.53			0.61	0.61	2720	246	0.40
44	2-year	7.69	16.2	6.80	12.5	16.6	0.000645	5.41			0.27	0.27	1770	257	0.36
44	10-year	7.69	18.0	8.19	13.8	18.7	0.000698	6.38			0.36	0.36	2250	271	0.39
44	25-year	7.69	18.8	8.80	14.3	19.5	0.000723	6.81			0.40	0.40	2460	275	0.40
44	50-year	7.69	19.3	9.26	14.7	20.1	0.000748	7.17			0.43	0.43	2600	276	0.41
44	100-year	7.69	19.8	9.69	15.1	20.7	0.000767	7.48			0.46	0.46	2740	277	0.42
43	2-year	4.65	15.5	7.65	10.7	15.9	0.000429	4.78			0.20	0.20	2000	258	0.30
43	10-year	4.65	17.2	8.89	12.0	17.8	0.000525	5.85			0.29	0.29	2460	271	0.34
43	25-year	4.65	17.9	9.27	12.5	18.6	0.000582	6.33			0.34	0.34	2650	281	0.36
43	50-year	4.65	18.4	9.59	13.0	19.1	0.000626	6.71			0.37	0.37	2780	285	0.38
43	100-year	4.65	18.8	9.78	13.4	19.6	0.000672	7.05			0.41	0.41	2910	292	0.39
42	2-year	0.83	15.0	10.7	7.77	15.3	0.000257	4.63			0.17	0.17	2070	1310	0.24
42	10-year	0.83	16.4	11.8	9.27	17.0	0.000397	6.15			0.29	0.29	2340	1330	0.31
42	25-year	0.83	17.0	12.2	9.94	17.7	0.000476	6.89			0.36	0.36	2430	1340	0.34
42	50-year	0.83	17.3	12.5	10.5	18.1	0.000550	7.49			0.43	0.43	2490	1340	0.36
42	100-year	0.83	17.5	12.7	10.9	18.5	0.000622	8.05			0.49	0.49	2540	1350	0.39
41.8	2-year	3.00	14.6	7.38	9.28	15.0	0.000431	5.34	0.55		0.24	0.20	1810	699	0.31
41.8	10-year	3.00	15.8	6.31	10.6	16.6	0.000643	7.00	1.42		0.40	0.25	2150	811	0.38
41.8	25-year	3.00	16.2	3.39	11.3	17.2	0.000774	7.85	1.06		0.50	0.16	2350	1170	0.42
41.8	50-year	3.00	16.4	3.60	11.8	17.5	0.000872	8.44	1.45		0.57	0.20	2520	1170	0.45
41.8	100-year	3.00	16.7	3.81	12.2	17.9	0.000953	8.94	1.81		0.64	0.23	2680	1180	0.47
41.5	2-year	4.50	14.6	4.84	8.86	14.8	0.000274	4.22	0.89		0.15	0.08	2440	920	0.25
41.5	10-year	4.50	15.8	5.27	10.1	16.2	0.000356	5.26	1.62		0.23	0.12	3150	1030	0.29
41.5	25-year	4.50	16.3	5.56	10.7	16.7	0.000404	5.76	1.95		0.27	0.14	3410	1060	0.31
41.5	50-year	4.50	16.5	5.78	11.1	17.1	0.000451	6.18	2.21		0.30	0.16	3570	1070	0.33
41.5	100-year	4.50	16.8	6.00	11.5	17.4	0.000490	6.54	2.45		0.34	0.18	3720	1090	0.35
41.2	2-year	5.50	14.2	4.48	10.1	14.5	0.000954	5.00	0.32		0.27	0.27	1920	421	0.41
41.2	10-year	5.50	15.4	5.52	11.4	15.9	0.000986	5.93	1.43		0.35	0.34	2430	433	0.44
41.2	25-year	5.50	15.7	5.80	12.0	16.4	0.00111	6.53	1.76		0.41	0.40	2580	437	0.47
41.2	50-year	5.50	15.8	5.93	13.1	16.6	0.00127	7.09	1.99		0.49	0.47	2640	438	0.50
41.2	100-year	5.50	16.0	6.05	13.6	16.9	0.00141	7.60	2.22		0.55	0.53	2710	440	0.53
41	2-year	5.91	12.5	3.12	11.2	13.6	0.00240	8.77		2.35	0.78	0.47	1180	375	0.67
41	10-year	5.91	13.6	2.53	13.6	14.9	0.00362	9.45		4.15	0.97	0.57	1760	690	0.80
41	25-year	5.91	14.3	1.88	14.3	15.4	0.00295	8.95		3.34	0.85	0.35	2400	1280	0.73
41	50-year	5.91	14.5	2.09	14.5	15.6	0.00282	9.04		3.62	0.85	0.37	2700	1290	0.72
41	100-year	5.91	14.7	2.23	14.7	15.8	0.00288	9.32		3.90	0.90	0.40	2900	1300	0.73
40	2-year	6.00	12.1	2.88	11.0	12.5	0.00152	5.90		4.13	0.39	0.27	1970	683	0.51
40	10-year	6.00	12.8	3.29	11.7	13.4	0.00186	6.96		5.11	0.52	0.38	2470	746	0.58
40	25-year	6.00	13.1	3.46	12.0	13.7	0.00202	7.42		5.54	0.58	0.44	2680	772	0.60
40	50-year	6.00	13.3	3.57	12.2	14.0	0.00216	7.81		5.88	0.64	0.48	2830	789	0.63
40	100-year	6.00	13.5	3.68	12.4	14.2	0.00227	8.12		6.17	0.69	0.52	2970	806	0.64
39	2-year	7.00	11.0	1.84	11.0	11.9	0.00612	8.79		6.17	0.99	0.70	1320	717	0.96
39	10-year	7.00	11.6	2.20	11.6	12.7	0.00607	9.56		7.11	1.12	0.84	1790	811	0.98
39	25-year	7.00	11.9	2.36	11.9	13.0	0.00594	9.79		7.43	1.16	0.88	2020	854	0.97
39	50-year	7.00	12.1	2.48	12.1	13.3	0.00580	9.78		7.67	1.15	0.90	2220	892	0.97
39	100-year	7.00	12.3	2.56	12.3	13.5	0.00595	9.92		8.01	1.18	0.95	2360	922	0.98

819 SE Morrison Street, Suite 310
Portland, Oregon 97214

VIGIL AGRIMIS, INC.

tel: 503-274-2010
fax: 503-274-2024
email: lmark@vigil-agrimis.com

Proposed Conditions Model With Downstream Boundary Condition = -4.4 feet-mllw

Cross-Section	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Hydr Radius (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Vel Left (ft/s)	Vel Right (ft/s)	Shear Chan (lb/sq ft)	Shear Total (lb/sq ft)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
49	2-year	6.04	17.4	6.68	12.7	17.9	0.00106	5.52			0.44	0.44	1740	255	0.37
49	10-year	6.04	19.6	7.03	14.1	20.1	0.00113	5.91			0.50	0.50	2430	339	0.39
49	25-year	6.04	20.4	7.82	14.7	21.0	0.00106	6.14			0.52	0.52	2730	342	0.38
49	50-year	6.04	21.1	8.40	15.2	21.7	0.00102	6.32			0.53	0.53	2950	344	0.38
49	100-year	6.04	21.7	8.94	15.7	22.4	0.000983	6.47			0.55	0.55	3160	346	0.38
48	2-year	1.06	16.9	8.05	10.5	17.3	0.000543	4.79			0.27	0.27	2000	241	0.29
48	10-year	1.06	18.9	9.12	12.6	19.5	0.000658	5.73			0.37	0.37	2510	267	0.33
48	25-year	1.06	19.8	9.67	13.4	20.4	0.000692	6.12			0.42	0.42	2740	275	0.34
48	50-year	1.06	20.4	10.2	14.0	21.1	0.000705	6.40			0.45	0.45	2920	277	0.35
48	100-year	1.06	21.0	10.7	14.5	21.7	0.000714	6.65			0.48	0.48	3080	279	0.35
47	2-year	2.55	16.5	7.72	11.4	16.9	0.000694	5.46			0.33	0.33	1750	223	0.34
47	10-year	2.55	18.4	9.16	12.8	19.0	0.000799	6.56			0.46	0.46	2190	233	0.38
47	25-year	2.55	19.2	9.86	13.5	20.0	0.000834	7.05			0.51	0.51	2380	234	0.39
47	50-year	2.55	19.8	10.4	14.0	20.6	0.000860	7.41			0.56	0.56	2520	235	0.40
47	100-year	2.55	20.3	10.9	14.5	21.3	0.000882	7.73			0.60	0.60	2650	236	0.41
46	2-year	4.94	16.4	8.24	11.4	16.8	0.000508	5.06			0.26	0.26	1890	226	0.31
46	10-year	4.94	18.2	9.83	12.8	18.8	0.000599	6.18			0.37	0.37	2320	231	0.34
46	25-year	4.94	19.0	10.5	13.3	19.7	0.000641	6.68			0.42	0.42	2510	233	0.36
46	50-year	4.94	19.6	11.0	13.8	20.4	0.000671	7.04			0.46	0.46	2650	235	0.37
46	100-year	4.94	20.2	11.4	14.2	21.0	0.000696	7.37			0.50	0.50	2780	237	0.38
45.5	Bridge														
45	2-year	4.21	16.3	7.86	11.7	16.7	0.000653	5.18			0.32	0.32	1850	231	0.32
45	10-year	4.21	18.2	9.44	13.0	18.8	0.000743	6.24			0.44	0.44	2300	238	0.35
45	25-year	4.21	19.0	10.1	13.6	19.7	0.000792	6.72			0.50	0.50	2490	242	0.37
45	50-year	4.21	19.6	10.5	14.0	20.4	0.000828	7.07			0.54	0.54	2640	245	0.38
45	100-year	4.21	20.2	10.9	14.4	21.0	0.000857	7.39			0.58	0.58	2770	247	0.39
44	2-year	7.69	16.1	6.72	12.5	16.6	0.000670	5.48			0.28	0.28	1748	257	0.37
44	10-year	7.69	18.0	8.21	13.8	18.7	0.000691	6.36			0.35	0.35	2260	271	0.39
44	25-year	7.69	18.9	8.87	14.3	19.6	0.000704	6.76			0.39	0.39	2480	275	0.40
44	50-year	7.69	19.5	9.40	14.7	20.2	0.000710	7.05			0.42	0.42	2650	277	0.40
44	100-year	7.69	20.0	9.89	15.1	20.8	0.000714	7.32			0.44	0.44	2800	278	0.41
43	2-year	4.65	15.4	7.56	10.7	15.8	0.000449	4.85			0.21	0.21	1980	257	0.31
43	10-year	4.65	17.3	8.91	12.0	17.8	0.000520	5.83			0.29	0.29	2470	272	0.34
43	25-year	4.65	18.0	9.35	12.5	18.6	0.000563	6.26			0.33	0.33	2680	281	0.36
43	50-year	4.65	18.6	9.68	13.0	19.3	0.000592	6.57			0.36	0.36	2840	288	0.37
43	100-year	4.65	19.1	9.99	13.4	19.9	0.000614	6.83			0.38	0.38	3000	295	0.38
42	2-year	0.83	14.9	10.6	7.77	15.2	0.000267	4.69			0.18	0.18	2040	1300	0.25
42	10-year	0.83	16.5	11.9	9.27	17.1	0.000393	6.13			0.29	0.29	2340	1330	0.31
42	25-year	0.83	17.1	12.3	9.94	17.8	0.000462	6.82			0.36	0.36	2460	1340	0.33
42	50-year	0.83	17.5	12.7	10.5	18.4	0.000517	7.34			0.41	0.41	2540	1350	0.35
42	100-year	0.83	18.0	13.0	10.9	18.9	0.000567	7.81			0.46	0.46	2620	1360	0.37
41.8	2-year	3.00	14.4	8.86	9.28	14.9	0.000456	5.43			0.25	0.25	1760	651	0.31
41.8	10-year	3.00	15.8	10.0	10.6	16.6	0.000659	7.09			0.41	0.41	2030	673	0.38
41.8	25-year	3.00	16.3	8.04	11.3	17.3	0.000780	7.91	0.67		0.51	0.39	2130	736	0.42
41.8	50-year	3.00	16.6	7.94	11.8	17.8	0.000875	8.54	1.13		0.58	0.43	2220	752	0.45
41.8	100-year	3.00	16.9	7.88	12.2	18.2	0.000960	9.10	1.49		0.66	0.47	2300	766	0.47
41.5	2-year	4.50	14.4	7.38	8.86	14.7	0.000303	4.38	0.91		0.16	0.14	2220	714	0.26
41.5	10-year	4.50	15.8	7.81	10.1	16.3	0.000404	5.58	1.59		0.25	0.20	2670	770	0.31
41.5	25-year	4.50	16.3	7.97	10.7	16.8	0.000466	6.18	1.88		0.31	0.23	2840	800	0.33
41.5	50-year	4.50	16.6	8.09	11.1	17.3	0.000514	6.64	2.11		0.35	0.26	2970	829	0.35
41.5	100-year	4.50	16.9	8.20	11.5	17.7	0.000555	7.03	2.31		0.39	0.28	3090	857	0.37
41.2	2-year	5.50	13.9	6.88	10.1	14.4	0.000709	5.79	1.43		0.31	0.30	1660	234	0.38
41.2	10-year	5.50	15.0	7.85	11.4	15.9	0.000986	7.50	2.31		0.50	0.46	1920	237	0.46
41.2	25-year	5.50	15.3	8.07	12.1	16.4	0.00121	8.47	2.71		0.63	0.61	1990	238	0.51
41.2	50-year	5.50	15.4	8.20	12.6	16.7	0.00141	9.27	3.02		0.75	0.72	2020	239	0.55
41.2	100-year	5.50	15.5	8.30	12.9	17.1	0.00163	10.0	3.32		0.87	0.84	2050	239	0.59
41	2-year	5.91	12.5	3.12	11.2	13.6	0.00240	8.77		2.35	0.78	0.47	1180	375	0.67
41	10-year	5.91	13.6	2.53	13.6	14.9	0.00362	9.45		4.15	0.97	0.57	1760	690	0.80
41	25-year	5.91	14.3	1.88	14.3	15.4	0.00295	8.95		3.34	0.85	0.35	2400	1270	0.73
41	50-year	5.91	14.5	2.09	14.5	15.6	0.00282	9.04		3.62	0.85	0.37	2700	1290	0.72
41	100-year	5.91	14.7	2.23	14.7	15.8	0.00288	9.32		3.90	0.90	0.40	2900	1300	0.73
40	2-year	6.00	12.1	2.88	11.0	12.5	0.00152	5.90		4.13	0.39	0.27	1970	683	0.51
40	10-year	6.00	12.8	3.29	11.7	13.4	0.00188	6.96		5.11	0.52	0.38	2470	746	0.58
40	25-year	6.00	13.1	3.46	12.0	13.7	0.00202	7.42		5.54	0.58	0.44	2680	772	0.60
40	50-year	6.00	13.3	3.57	12.2	14.0	0.00216	7.81		5.88	0.64	0.48	2830	789	0.63
40	100-year	6.00	13.5	3.68	12.4	14.2	0.00227	8.12		6.17	0.69	0.52	2970	806	0.64
39	2-year	7.00	11.0	1.84	11.0	11.9	0.00612	8.79		6.17	0.99	0.70	1320	717	0.96
39	10-year	7.00	11.6	2.20	11.6	12.7	0.00607	9.56		7.11	1.12	0.84	1790	811	0.98
39	25-year	7.00	11.9	2.36	11.9	13.0	0.00594	9.79		7.43	1.16	0.88	2020	854	0.97
39	50-year	7.00	12.1	2.48	12.1	13.3	0.00580	9.78		7.67	1.15	0.90	2210	892	0.97
39	100-year	7.00	12.3	2.56	12.3	13.5	0.00595	9.92		8.01	1.18	0.95	2360	922	0.98

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