Devils Creek at Kodiak, Hydrology and Hydraulic Study, HDR, March, 2014

Kodiak Airport
Devils Creek Culvert Repair
Project No. 57474/AIP 3-02-0158-01x-201x

Devils Creek at Kodiak Airport

Hydrology and Hydraulic Study

FINAL REPORT

Prepared for:

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Central Region
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March 2014

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1.0 PROJECT DESCRIPTION

The purpose of this report is to:

- Evaluate the hydrology of Devils Creek at the Kodiak Airport Culvert.
- Evaluate the hydraulic capacity of the existing twin box culvert that conveys Devils Creek under Taxiway D and Runway 7/25 of the Kodiak Airport.
- Evaluate debris issues and their impact on culvert capacity and propose methods for debris management.
- Provide recommendations for dealing with culvert overflow, if needed.

A location and vicinity map are shown on Figure 1 in Appendix B.

2.0 BACKGROUND

Devils Creek flows beneath the Kodiak Airport in a twin box concrete culvert. This culvert was constructed prior to 1951 and extended on its upstream end in 1951. Kodiak maintenance and operations crews report that localized flooding at the Devils Creek culvert commonly occurs, often as a result of ice or debris accumulation at the inlet. The most recent overtopping event was reported during the week of October 4-10, 2009. That event resulted in flow over the taxiway parallel to runway 7/25.

Previous work on this culvert includes:

- A Hydrology and Hydraulics Review by the Alaska Department of Transportation dated July 2, 2010. This review was based on a site visit on March 9, 2010.
- A memorandum from Paul Janke of the Alaska Department of Transportation dated June 30, 2011. This memorandum was based on a site visit on June 20, 2011.

Bob Butera, P.E. of HDR Alaska, Inc. completed a reconnaissance of the project on October 19, 2012. Ray Gamradt, also of HDR Alaska, Inc., performed a previous structural reconnaissance on August 27, 2012. Photographs taken during the site reconnaissance are included in Appendix A. The structural reconnaissance is documented in a separate report and recommends resurfacing of the eroded invert of the twin box concrete culvert.

3.0 HYDROLOGY

The basin characteristics of Devils Creek at the Kodiak Airport are listed in Table 1.

Table 1. Devils Creek Basin Characteristics

Drainage Area	4	square miles
Area of Lakes and Ponds	0	%
Mean Basin Elevation	1000	feet
Mean Annual Precipitation	100	inches
Mean Minimum January Temp	24°	F

The U.S. Geological Survey (USGS) map of this area is not clear on the direction of the drainage from the southwest side of Erskine Mountain. Based on the review of aerial photography, this basin is observed to flow into Devils Creek, resulting in the listed drainage area of 4 square miles.

There are no stream gauging records for Devils Creek. The nearest river with continuous gauging data is Myrtle Creek, near Kodiak (POR=1963 to present for peak flow data; DA = 4.74 square miles; area of lakes and ponds = 0%, mean basin elevation = 700 feet). Myrtle Creek is 11 miles south of Devils Creek. The two creeks have similar aspects. Devils Creek has a slightly higher mean basin elevation.

Table 2 provides a comparison of estimated Devils Creek flood flows. Column 2 of Table 2 shows the estimated flood discharge for Myrtle Creek, based on the peak flow data records. Column 3 shows the estimated flood discharges of Devils Creek based on a direct drainage area comparison to Myrtle Creek (4.0/4.74=0.84). Column 4 shows the flood discharge for Devils Creek based on the Area 3 regression equations and methodology contained in "Estimating the Magnitude and Frequency of Peak Streamflows for Ungaged Sites on Streams in Alaska and Conterminous Basins in Canada" (USGS Water Resources Investigations Report 03-4188, 2003).

Table 2. Estimated Devils Creek Flood Flows

1	2	3	4
Recurrence Interval (years)	**Myrtle Creek Discharge Based on Gage Record (cfs)**	**Devils Creek Discharge Based on Myrtle Creek (cfs)**	**Devils Creek Discharge Based on USGS Regression (cfs)**
2	855	720	630
5	1,050	890	890
10	1,160	990	1,070
25	1,300	1,110	1,290
50	1,390	1,190	1,460
100	1,480	**1,280**	1,620
200	1,560	1,360	1,790
500	1,670	1,470	2,010

4.0 DESIGN STORM

FAA Advisory Circular 150/5320-5D for Airport Drainage Design Section 4-3 Design Storm states:

> Protection of facilities against flood flows originating from areas exterior to the facility will normally be based on local design requirements but not less than the 10-year event. Operational requirements, cost-benefit considerations, and the nature and consequences of flood damage resulting from the failure of protective works shall also be considered.

Justification for the selected design storm will be presented, and, if appropriate, comparative costs and damages for alternative designs should be included.

To avoid interruption of airport operations we believe the culvert design frequency should be the same as a culvert on a primary highway. The Alaska Highway Preconstruction Manual specifies this as the 50-year recurrence interval (Q50). As the 100-year recurrence interval is only slightly greater, it should be used. Myrtle Creek was judged to be a good proxy for Devils Creek as it is nearby, has similar drainage basin characteristics, and has 48 years of flood records. The recommended design flood flow is 1,280 cubic feet per second (cfs) based on the recorded flows in Myrtle Creek (see bold items in Table 2).

5.0 HYDRAULICS

The existing culvert is a concrete box culvert approximately 790 feet long. It is composed of two side-by-side sections that are 10 feet wide by 6 feet high. There are 15 degree concrete wing walls and a concrete apron at the inlet. The original culvert is approximately 500 feet long, is straight and has a slope of 1 percent. An additional 276-foot-long curving segment of culvert with a slope of 0.4 percent was added to the upstream end in 1951. Record drawings dated October 25, 1951 (Appendix B) show an inlet invert elevation of 163.1 and the top of the concrete box culvert at the inlet as 170.35. The existing finish grade at the culvert inlet is the top of the concrete box culvert, elevation 170.35. There is a 1–foot-tall concrete curb at the top of the culvert.

The existing culvert has a debris rack installed at the face of the inlet. The existing debris rack was installed after the October 2009 storm. The prior debris rack was more vertical with less open area between the bars. Therefore, the existing debris rack should be less susceptible to clogging by debris than the debris rack that existed during the October 2009 storm. If this rack contains debris or ice it will greatly limit flows in this culvert. Hydraulic calculations assume no debris rack (see Section 7.0, Sediment Evaluation).

The existing culvert has approximately a 1 foot depth of angular cobbles deposited in both sides of the inlet. This deposition will be removed to resurface the invert of the box culverts. Hydraulic calculations assume the deposition is removed, the bottom resurfaced and that future maintenance includes sediment removal if necessary.

Hydraulic Design. Hydraulic evaluation of the Devils Creek culvert was calculated using the methods provided in Hydraulic Design of Highway Culverts (FHWA 1985) and checked using HY8. Headwater elevations for various flood recurrence intervals are shown in Table 3. Calculations are provided in Appendix C.

Table 3. Devils Creek Hydrologic and Hydraulic Summary

Recurrence Interval	Q_{10}	Q_{50}	Q_{100}
Exceedance probability (%)	10	2	1
Design discharge (cfs)	990	1,190	1,280
Headwater elevation [1]	170.3	171.5	172.4[2]
Control	Inlet	Inlet	Inlet

[1] The datum for this report is the 1951 record drawings for the Devils Creek Culvert

[2] Elevation assumes berms constructed to allow increased headwater.

Hydraulics are based on the upstream 276 feet of culvert for which elevation data is available. As inlet conditions controlled the headwater elevation for all flow cases, the results are not expected to change for the longer culvert, since the original downstream section of culvert is steeper than the more recent upstream section and there is a small waterfall just downstream of the culvert outlet.

The headwater elevation for the Q10 is equivalent to the outside top of the box culvert, which is also the local ground elevation. The headwater elevation for the Q100 is 2 feet above the local ground elevation.

To pass the design flow (100-year recurrence), the headwater will need to be increased. Raising the finish grade at the inlet with a 3-foot-tall berm will allow the culvert to pass the 100-year flow with a foot of freeboard. The total capacity of the culvert with this berm will be approximately 1400 cfs.

The inlet hydraulics can be improved by rounding the square inlet edges. The decrease in headwater due to this change is minor and cannot be calculated. This improvement is still considered worthwhile.

The original 500 foot long portion of the east culvert has an 8" concrete encased pressure sewer line along its bottom on its east (right side). The dimensions of this concrete encasement are approximately 2-foot-wide x 1.5–foot-tall. The protrusion of this concrete into the culvert may be causing a slight backwater, potentially causing deposition in the upstream section of the culvert. Relocation of this sewer would provide a consistent culvert section but would require open cut replacement of approximately 500 feet of pressure sewer line; a portion of this across the primary runway. From a culvert hydraulics perspective, removal of this sewer is not justified. However, since the bottom of the box culvert is to be resurfaced and this pipe is over 39 years old (it is shown as existing on a 1974 Apron and Taxiway Plan), DOT&PF may want to evaluate the replacement of this pipe along with the structural rehabilitation of the culvert.

6.0 DEBRIS EVALUATION

The July 2, 2010 ADOT Hydrology and Hydraulics Review for this project stated that Kodiak Maintenance and Operations crews reported that localized flooding near the Devils Creek culvert inlet is common, often the result of ice or debris accumulation at the inlet.

Potential sources of debris in Devils Creek were evaluated in the field. The length of the stream was walked from the inlet of the airport box culvert, ½ mile upstream to an abandoned concrete dam. Potential sources of debris from upstream to downstream are as follows:

- Upstream of concrete dam:
    - There are few trees upstream of the dam and sources of debris would be primarily brush. A caveat to this is that trees are starting to colonize this area of Kodiak and within the design life of this culvert will likely cause debris issues. An accumulation of brush was noted on the riser of a gate valve at the dam. Removal of the concrete stoplog support, stoplog, and the valve riser would minimize the potential for a debris jam at the dam site.
- Between the concrete dam and Rezanoff Drive:

  - Small trees are taking hold in this area and future bank erosion will transport them downstream.
  - A large abandoned concrete intake structure for a relic wooden box culvert (described below) is located immediately upstream of Rezanoff Drive. This structure has caused extensive bank erosion as the stream attempts to bypass it. Stabilization of the banks with riprap has resolved this problem for the present, but the intake structure may be causing ice problems (see below).
- Between Rezanoff Drive and Airport Maintenance Road Bridge:
  - The floor and partial height sidewalls of a relic wooden box culvert exist in about 400 linear feet of this reach. Ideally these would be removed as, over time, the wood will wash out, and potentially cause downstream debris issues.
- Between Airport Maintenance Road Bridge and Airport Box Culvert:
  - The form boards of the concrete airport maintenance road bridge were recently removed. These were a source of past debris.
  - There are no trees in this section large enough to plug the box culverts. Removal of saplings before they mature is recommended.

In summary, there should be a method to catch debris before it gets to the box culvert to prevent entrapment of the debris in the box culvert. The existing location at the inlet to the box culverts does not work because if it plugs water will overflow the runway. The selected location for a new debris rack is upstream of the box culverts to allow flow to bypass the rack if it becomes plugged. Debris rack design will be based on Hydraulic Engineering Circular 9, Debris Control Structures,

7.0 ICE EVALUATION

Maintenance personnel reported that there was at least one occurrence of an ice jam somewhere upstream that impounded water and sent a large flow of water and ice downstream when it released. Maintenance personnel suspect that this jam occurred at Rezanoff Drive. The existing conveyance structure at Rezanoff Drive is a 12-foot-diameter aluminum corrugated metal pipe. High water debris was observed approximately 4 feet above the top of the inlet of this culvert. Downstream of the Rezanoff Drive culvert in the straight segment of creek with the relic timber box culvert, high water debris was found 8 feet above the channel bottom. A flow of approximately 3,000 cfs would be required to produce this depth in this channel. Likely the debris was deposited during the ice jam release.

The mechanism of this jamming is unknown and is likely affected by the existing relic concrete inlet box. Removal of all or a portion of this relic structure and realignment of the channel in this area will improve the hydraulics of the Rezanoff Drive culvert inlet and may reduce future ice jamming.

8.0 SEDIMENT EVALUATION

The headwaters of Devils Creek are very steep (>20 percent), barren, and a significant source of sediment, evidenced by a braided portion of stream that follows this steep section. The creek has

a steady gradient of 2 to 3 percent to Rezanoff Drive and significant bank erosion was observed in the section of creek between the concrete dam and Rezanoff Drive. Downstream of Rezanoff Drive, the slope through the relic wooden box culvert to the inlet of the box culverts is 1 to 2 percent. The slope of the upstream 276 feet (newer portion) of the box culvert is 0.4 percent. The slope of the downstream 500 feet (older portion) of the box culvert is 1 percent. This change in slope is noticeable as there is sediment in the newer, flatter, section of the culvert and no sediment in the older, steeper, section of the culvert.

At the time of the site visit, the Devils Creek culvert had approximately 1 foot of angular cobbles deposited at the inlet. In the east (right, looking downstream) box, this deposition extends downstream the full length of the newer portion of culvert (276 feet) with the amount of deposition decreasing quickly in a downstream direction, and deposition beyond the upstream 50 feet of culvert is minor and is primarily on the inside bend of the culvert. The west box carried the majority of the flow at the time of our reconnaissance and deposition was unable to be observed, but review of photos from the August 27, 2012 structural reconnaissance, showed it had deposition extending approximately 50 feet downstream of the inlet. In theory, this deposition may reoccur as the upstream channel has slightly higher tractive forces than the upstream portion of the culvert. In practice, observed deposition decreased quickly downstream of the inlet, indicating it may have been initiated by the original debris rack at the inlet.

Retaining the existing debris rack in addition to the upstream debris rack was considered. This was felt to be unnecessary with the new rack and removal of the existing rack would minimize potential for sediment deposition. The sediment transport balance at the inlet of the box culvert is slanted towards deposition at the culvert inlet and the inclusion of a debris rack at this location could further tip the balance towards deposition. If deposition does occur, a debris rack would make maintenance more difficult. In any case only one debris rack is needed and an additional rack would only require additional maintenance.

9.0 SUMMARY

Table 4 summarizes the hydrologic and hydraulic design values for the existing Devils Creek culvert.

Table 4. Hydrologic and Hydraulic Summary for Devils Creek

Drainage Area	**4 square miles**	
Exceedance probability (%)	2	1
Return period	50-Year (Q_{50})	100-Year (Q_{100})
Design discharge (cfs)	1190	1280
Design high water elevation [1]	171.5	172.4 [2]

[1] The datum for this report is the 1951 record drawings for the Devils Creek Culvert

[2] Elevation assumes berms constructed to allow increased headwater.

The capacity of the existing structure is 990 cfs at the elevation of the top of the box culvert and local finish grade, which has an exceedance probability equal to or less than 10 percent (Q_{10}). This assumes the existing debris rack and deposited sediment are removed and the culvert bottom resurfaced.

Recommendations

Recommendations should be constructed as a total package and are shown on Drawings 1 and 2 (Appendix B). Recommendations in an upstream-to-downstream order are as follows:

1. Remove concrete stoplog support, stoplog, and valve riser at abandoned concrete dam.
2. Remove all or a portion of the abandoned concrete inlet structure upstream of Rezanoff Drive.
3. Remove remnants of the relic wooden box culvert between the maintenance access road and Rezanoff Drive.
4. Construct a new debris rack upstream of the box culvert.
5. Remove the existing debris rack at the box culvert inlet.
6. Round the edges of the box culvert inlet to increase flow entrance efficiency, remove the sediment from the box and resurface the bottom of the box culverts.
7. Construct a berm to elevation 173.4 at the inlet of the box culvert.

Appendix A: Reconnaissance Photographs

All photos taken October 19, 2012
Photograph order is upstream to downstream

Abandoned concrete dam–note brush debris on valve operator. Stoplog support in center of photo. Photograph looking upstream.

Abandoned wooden bridge
Photograph looking downstream. (Post note: Bridge was removed in 2012)

Abandoned concrete inlet structure–note Rezanoff Drive 12-foot-diameter aluminum CMP in background and riprap on left bank.
Photograph looking downstream.

Inlet to Rezanoff Drive 12-foot-diameter aluminum CMP–note flood debris above culvert inlet.
Photograph looking downstream.

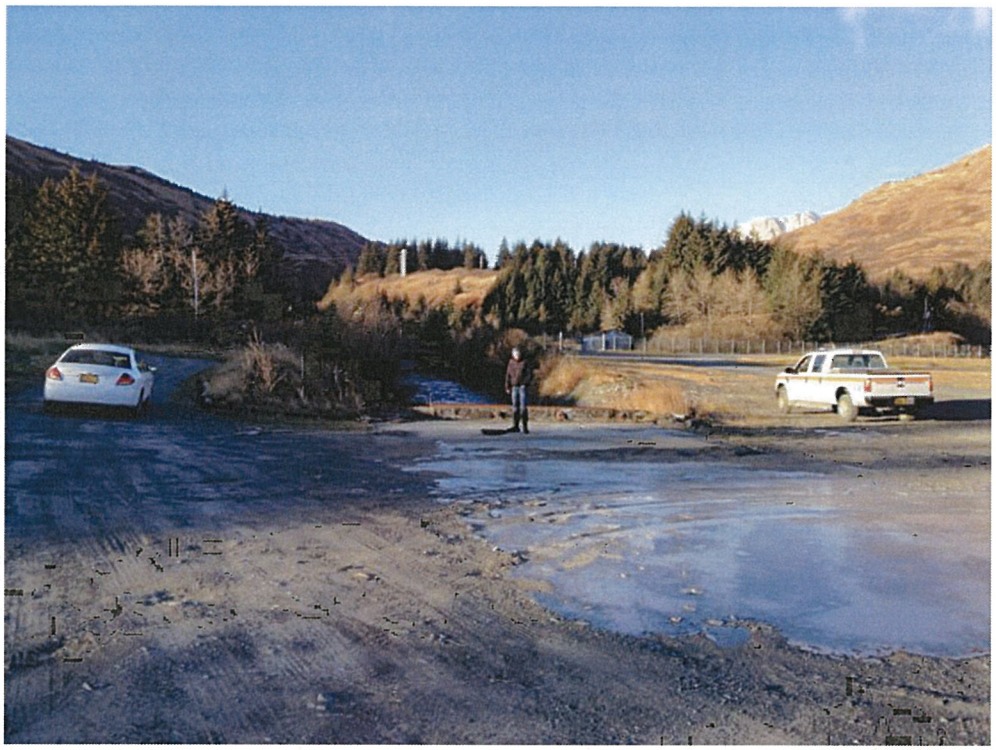
Remnants of relic wooden box culvert between Rezanoff Drive and maintenance road bridge. Photograph looking upstream.

Relic wooden box culvert; detail of timber bottom.

Maintenance road bridge–note airport culvert intake in background.

Photograph looking downstream.

Airport culvert intake and debris rack.
Photograph looking downstream.



Airport culvert intake
Photograph looking upstream

Airport culvert intake–note sharp edges on concrete inlet and gravel in invert.
Photograph looking downstream.

Airport culvert outlet–note concrete encased pressure sewer in culvert on left side of photo.
Photograph looking upstream

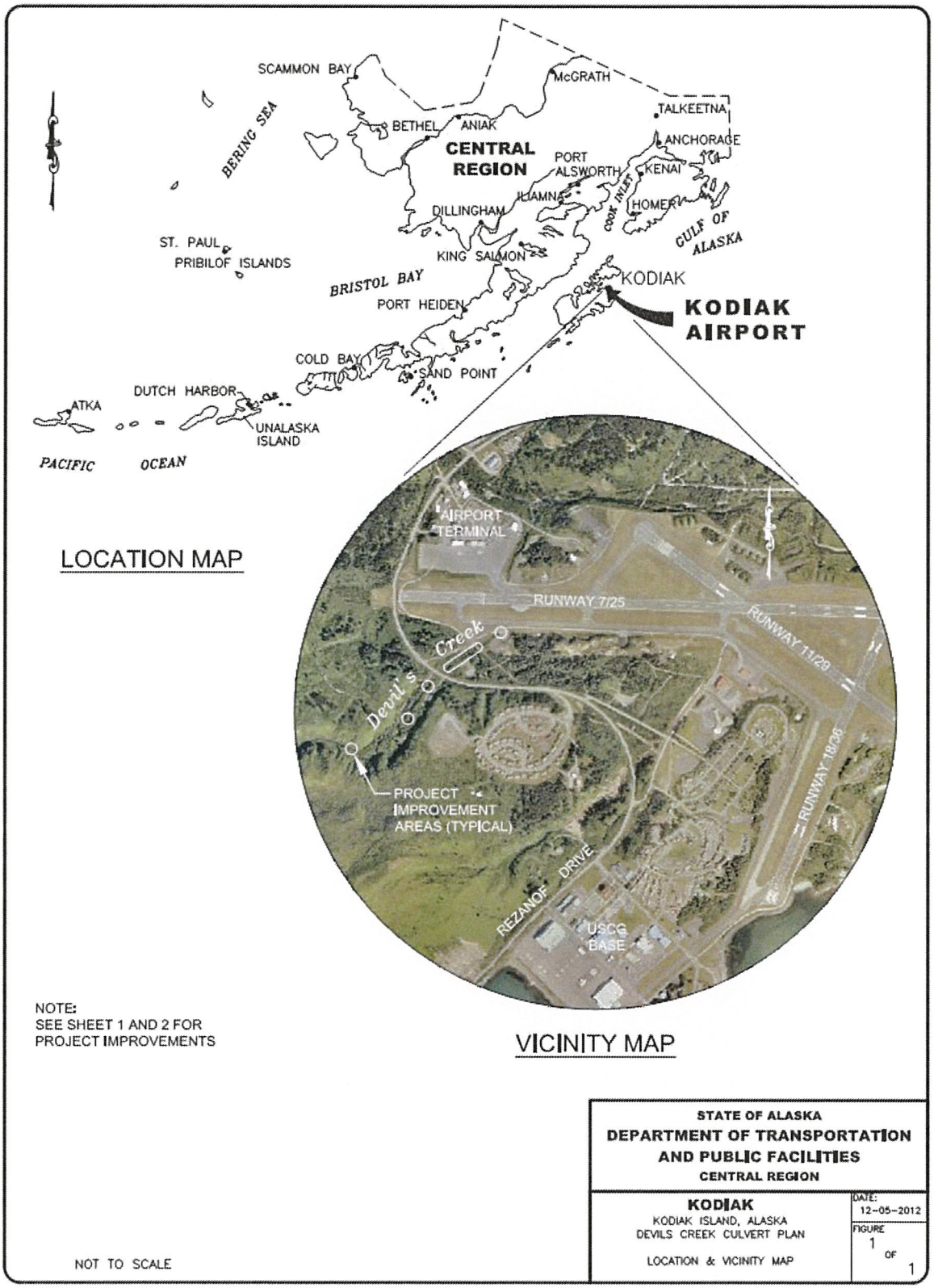
Airport culvert outlet. Detail of concrete encased pressure sewer in culvert.
Photograph looking upstream

Tailwater section for airport culvert outlet.
Photograph looking downstream

Waterfall downstream of airport culvert outlet.

Appendix B: Drawings

Location and Vicinity Map
Drawing 1 of 2 - Proposed Improvements
Drawing 2 of 2 - Proposed Improvements
Record Drawing for Taxiway Extension dated October 25, 1951


SCAMMON BAY
McGRATH
TALKEETNA
BETHEL
ANIAK
CENTRAL REGION
ANCHORAGE
PORT ALSWORTH
KENAI
BERING SEA
ILIAMNA
COOK INLET
HOMER
DILLINGHAM
GULF OF ALASKA
ST. PAUL
PRIBILOF ISLANDS
KING SALMON
KODIAK
BRISTOL BAY
PORT HEIDEN
KODIAK AIRPORT
COLD BAY
SAND POINT
DUTCH HARBOR
ATKA
UNALASKA ISLAND
PACIFIC OCEAN
LOCATION MAP
AIRPORT TERMINAL
RUNWAY 7/25
RUNWAY 11/29
Devil's Creek
RUNWAY 18/36
PROJECT IMPROVEMENT AREAS (TYPICAL)
REZANOF DRIVE
USCG BASE
VICINITY MAP
NOTE:
SEE SHEET 1 AND 2 FOR PROJECT IMPROVEMENTS
NOT TO SCALE
STATE OF ALASKA
DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES
CENTRAL REGION
KODIAK
KODIAK ISLAND, ALASKA
DEVILS CREEK CULVERT PLAN
LOCATION & VICINITY MAP
DATE: 12-05-2012
FIGURE 1 OF 1

PROPOSED IMPROVEMENTS PROJECT AREA PLAN

NOT TO SCALE

PHOTOGRAPH LOOKING UPSTREAM

(1) REMOVE CONCRETE STOP-LOG SUPPORT AND STOP-LOG AT ABANDONED CONCRETE DAM

PHOTOGRAPH LOOKING DOWNSTREAM

(2) REMOVE ABANDONED RELIC WOODEN BRIDGE

PHOTOGRAPH LOOKING DOWNSTREAM

(3) REMOVE RELIC CONCRETE INLET STRUCTURE

PHOTOGRAPH LOOKING DOWNSTREAM

(4) REMOVE REMNANTS OF RELIC WOODEN BOX CULVERT

NOTE:
SEE DETAIL SHEET 2 FOR PHOTO ID NUMBERS 5, 6, 7, 8 AND 9

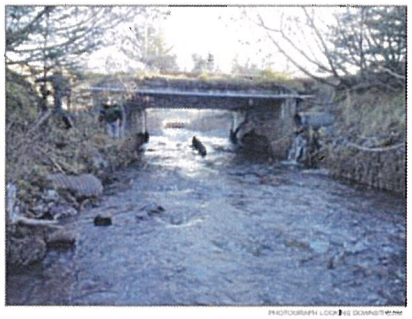
STATE OF ALASKA
DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES
CENTRAL REGION

KODIAK
KODIAK ISLAND, ALASKA
DEVILS CREEK CULVERT PLAN

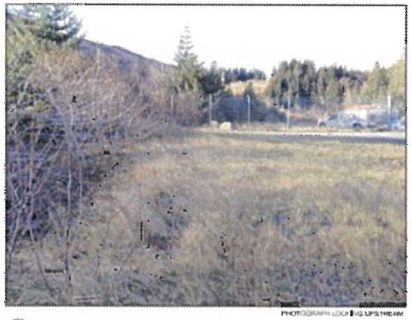
PROPOSED IMPROVEMENTS

DATE: 12-05-2012
SHEET: 1 OF 2

PROPOSED IMPROVEMENTS DETAIL
NOT TO SCALE



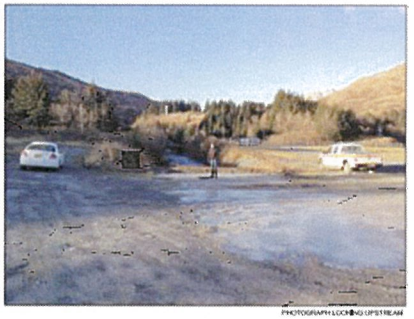
(5) CONSTRUCT NEW DEBRIS RACK



(6) CONSTRUCT NEW OVERFLOW CHANNEL AND FORD

(7) REMOVE EXISTING DEBRIS RACK

(8) ROUND THE EDGES OF EXISTING BOX CULVERT INLET AND REMOVE SEDIMENT FROM CULVERT



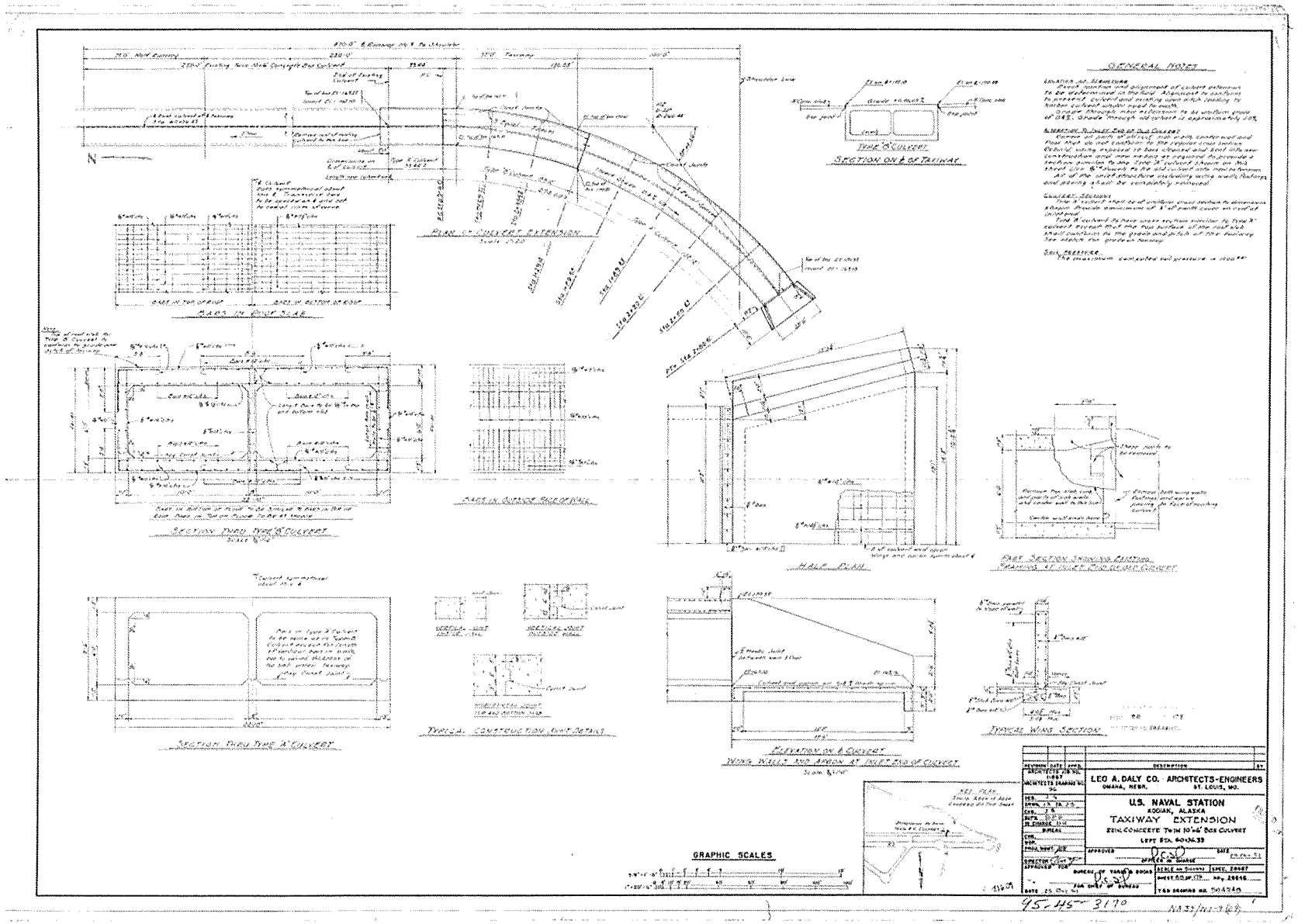
(9) CONSTRUCT NEW 3-FOOT TALL BERM

NOTE:
SEE SHEET 1 FOR OTHER PROJECT IMPROVEMENTS

STATE OF ALASKA
DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES
CENTRAL REGION

KODIAK
KODIAK ISLAND, ALASKA
DEVILS CREEK CULVERT PLAN
PROPOSED IMPROVEMENTS

DATE: 12-05-2012
SHEET: 2 OF 2


GENERAL NOTES
PLAN OF CULVERT EXTENSION
SECTION ON ℄ OF TAXIWAY
TYPE 'A' CULVERT
MAPS IN ENVIR SCAR
SECTION THRU TYPE 'A' CULVERT
MAPS IN INVERT PAVE OF WALL
HALF PLAN
PART SECTION SHOWING ARRANGEMENT OF STEEL REINFORCEMENT
TYPICAL CONSTRUCTION JOINT DETAILS
ELEVATION ON ℄ CULVERT
WING WALLS AND APRON AT INLET END OF CULVERT
TYPICAL WING SECTION
SECTION THRU TYPE 'A' CULVERT
GRAPHIC SCALES
LEO A. DALY CO. - ARCHITECTS-ENGINEERS
OMAHA, NEBR. ST. LOUIS, MO.
U.S. NAVAL STATION
KODIAK, ALASKA
TAXIWAY EXTENSION
REINFORCED CONCRETE TWIN 10'-6" BOX CULVERT
LEFT STA. 604+36.33
BUREAU OF YARDS & DOCKS
95-NAS-3179

Appendix C: Hydrology and Hydraulic Computations

Regression Equation Output:

```
This program computes estimates of T-year floods
 for ungaged sites in Alaska based on the
 report "Estimating the Magnitude and Frequency of Peak
 Streamflows for Ungaged Sites on Streams in Alaska and
 Conterminous Basins in Canada", WRIR 03-4188
 See the above publication for equations
* No warranty, expressed or implied, is made by the
* USGS as to the accuracy and functioning of the
* program and related program material.
  VERSION 10/04/03
 ++++++++++++++++++++++++++++++++++++++++++++++++++


 Flood frequency estimates for
 Site: Devil1
 Region 1 or 3
 Drainage area, in square miles:                    4.00
 Percent of area in lakes and ponds:                0.0
 Mean annual precip, in inches:                   100.0
 Mean min January temp., degrees F:                24.0
```

T	DISCHARGE (cfs)	SE (+%)	SE(-%)	CONFIDENCE LIMITS 5%	CONFIDENCE LIMITS 95%	EQ. YEARS
2	629.	43.4	-30.3	345.	1140.	1.0
5	889.	42.7	-29.9	493.	1600.	1.6
10	1070.	43.0	-30.1	589.	1930.	2.2
25	1290.	44.3	-30.7	701.	2370.	2.9
50	1460.	45.8	-31.4	779.	2720.	3.5
100	1620.	47.7	-32.3	846.	3090.	3.9
200	1790.	49.9	-33.3	913.	3510.	4.3
500	2010.	53.3	-34.8	989.	4090.	4.6

Bulletin 17B PKFLDW in Output For Myrtle Creek Records

```
1
  Program PeakFq           U. S. GEOLOGICAL SURVEY              Seq.000.000
  Ver. 5.2            Annual peak flow frequency analysis       Run Date /
Time
  11/01/2007          following Bulletin 17-B Guidelines        09/24/2012
10:22

                        --- PROCESSING OPTIONS ---

                        Plot option         = None
                        Basin char output   = None
                        Print option        = Yes
                        Debug print         = No
                        Input peaks listing = Long
                        Input peaks format  = WATSTORE peak file


  Program PeakFq           U. S. GEOLOGICAL SURVEY              Seq.001.001
  Ver. 5.2            Annual peak flow frequency analysis       Run Date /
Time
  11/01/2007          following Bulletin 17-B Guidelines        09/24/2012
10:22

                  Station - 15297200  MYRTLE C NR KODIAK AK


                     I N P U T   D A T A   S U M M A R Y

                  Number of peaks in record            =       49
                  Peaks not used in analysis           =        0
                  Systematic peaks in analysis         =       49
                  Historic peaks in analysis           =        0
                  Years of historic record             =        0
                  Generalized skew                     =    0.700
                       Standard error                  =    0.550
                       Mean Square error               =    0.303
                  Skew option                          =   WEIGHTED
                  Gage base discharge                  =      0.0
                  User supplied high outlier threshold =   --
                  User supplied low outlier criterion  =   --
                  Plotting position parameter          =     0.00


  *********  NOTICE  --  Preliminary machine computations.          *********
  *********  User responsible for assessment and interpretation.   *********

    WCF134I-NO SYSTEMATIC PEAKS WERE BELOW GAGE BASE.                    0.0
    WCF198I-LOW OUTLIERS BELOW FLOOD BASE WERE DROPPED.       1        407.8
    WCF163I-NO HIGH OUTLIERS OR HISTORIC PEAKS EXCEEDED HHBASE.       1659.7
1


  Program PeakFq           U. S. GEOLOGICAL SURVEY              Seq.001.002
  Ver. 5.2            Annual peak flow frequency analysis       Run Date /
Time
  11/01/2007          following Bulletin 17-B Guidelines        09/24/2012
10:22
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Station - 15297200 MYRTLE C NR KODIAK AK

ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

	FLOOD BASE		LOGARITHMIC		
	DISCHARGE	EXCEEDANCE PROBABILITY	MEAN	STANDARD DEVIATION	SKEW
SYSTEMATIC RECORD	0.0	1.0000	2.9262	0.1144	-0.736
BULL.17B ESTIMATE	407.8	0.9796	2.9303	0.1057	-0.088

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED PROBABILITY' ESTIMATE	95-PCT CONFIDENCE LIMITS FOR BULL. 17B ESTIMATES LOWER	UPPER
0.9950	--	357.9	--	--	--
0.9900	--	398.4	--	--	--
0.9500	567.4	521.5	560.2	511.9	614.2
0.9000	622.2	593.7	617.3	569.5	667.5
0.8000	694.8	685.9	692.0	645.4	739.2
0.6667	769.2	775.4	768.0	721.9	814.9
0.5000	854.8	871.2	854.8	806.7	905.9
0.4292	892.6	911.1	893.1	843.0	947.7
0.2000	1046.0	1057.0	1050.0	983.3	1127.0
0.1000	1161.0	1151.0	1169.0	1082.0	1267.0
0.0400	1294.0	1244.0	1311.0	1194.0	1437.0
0.0200	1388.0	1301.0	1413.0	1271.0	1559.0
0.0100	1476.0	1348.0	1512.0	1342.0	1677.0
0.0050	1562.0	1389.0	1610.0	1410.0	1792.0
0.0020	1671.0	1435.0	1738.0	1497.0	1941.0

1

Program PeakFq Ver. 5.2 — U. S. GEOLOGICAL SURVEY — Annual peak flow frequency analysis following Bulletin 17-B Guidelines — Seq.001.003 — Run Date / Time 11/01/2007 10:22 — 09/24/2012

Station - 15297200 MYRTLE C NR KODIAK AK

I N P U T D A T A L I S T I N G

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
1963	797.0		1988	775.0	
1964	442.0		1989	780.0	
1965	553.0		1990	1180.0	
1966	620.0		1991	1160.0	
1967	648.0		1992	1020.0	
1968	908.0		1993	980.0	
1969	1110.0		1994	1100.0	

1970	741.0	1995	1070.0
1971	694.0	1996	652.0
1972	808.0	1997	847.0
1973	832.0	1998	1180.0
1974	705.0	1999	1190.0
1975	500.0	2000	385.0
1976	675.0	2001	832.0
1977	1350.0	2002	879.0
1978	822.0	2003	823.0
1979	1180.0	2004	1080.0
1980	818.0	2005	764.0
1981	790.0	2006	1020.0
1982	734.0	2007	966.0
1983	731.0	2008	899.0
1984	910.0	2009	899.0
1985	899.0	2010	1250.0
1986	865.0	2011	756.0
1987	1070.0		

Explanation of peak discharge qualification codes

PeakFQ CODE	NWIS CODE	DEFINITION
D	3	Dam failure, non-recurrent flow anomaly
G	8	Discharge greater than stated value
X	3+8	Both of the above
L	4	Discharge less than stated value
K	6 OR C	Known effect of regulation or urbanization
H	7	Historic peak

- Minus-flagged discharge -- Not used in computation
  -8888.0 -- No discharge value given
- Minus-flagged water year -- Historic peak used in computation

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.004
Ver. 5.2 Annual peak flow frequency analysis Run Date / Time
11/01/2007 following Bulletin 17-B Guidelines 09/24/2012 10:22

Station - 15297200 MYRTLE C NR KODIAK AK

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
1977	1350.0	0.0200	0.0200
2010	1250.0	0.0400	0.0400
1999	1190.0	0.0600	0.0600
1979	1180.0	0.0800	0.0800
1990	1180.0	0.1000	0.1000
1998	1180.0	0.1200	0.1200
1991	1160.0	0.1400	0.1400
1969	1110.0	0.1600	0.1600

1994	1100.0	0.1800	0.1800
2004	1080.0	0.2000	0.2000
1987	1070.0	0.2200	0.2200
1995	1070.0	0.2400	0.2400
1992	1020.0	0.2600	0.2600
2006	1020.0	0.2800	0.2800
1993	980.0	0.3000	0.3000
2007	966.0	0.3200	0.3200
1984	910.0	0.3400	0.3400
1968	908.0	0.3600	0.3600
1985	899.0	0.3800	0.3800
2008	899.0	0.4000	0.4000
2009	899.0	0.4200	0.4200
2002	879.0	0.4400	0.4400
1986	865.0	0.4600	0.4600
1997	847.0	0.4800	0.4800
1973	832.0	0.5000	0.5000
2001	832.0	0.5200	0.5200
2003	823.0	0.5400	0.5400
1978	822.0	0.5600	0.5600
1980	818.0	0.5800	0.5800
1972	808.0	0.6000	0.6000
1963	797.0	0.6200	0.6200
1981	790.0	0.6400	0.6400
1989	780.0	0.6600	0.6600
1988	775.0	0.6800	0.6800
2005	764.0	0.7000	0.7000
2011	756.0	0.7200	0.7200
1970	741.0	0.7400	0.7400
1982	734.0	0.7600	0.7600
1983	731.0	0.7800	0.7800
1974	705.0	0.8000	0.8000
1971	694.0	0.8200	0.8200
1976	675.0	0.8400	0.8400
1996	652.0	0.8600	0.8600
1967	648.0	0.8800	0.8800
1966	620.0	0.9000	0.9000
1965	553.0	0.9200	0.9200
1975	500.0	0.9400	0.9400
1964	442.0	0.9600	0.9600
2000	385.0	0.9800	0.9800

1

```
 End PeakFQ analysis.
   Stations processed :       1
   Number of errors   :       0
   Stations skipped   :       0
   Station years      :      49

Data records may have been ignored for the stations listed below.
(Card type must be Y, Z, N, H, I, 2, 3, 4,  or *.)
(2, 4, and * records are ignored.)

 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:  15297200       USGS MYRTLE C NR KODIAK AK
```

PROJECT: Kodiak, Devil Creek at Kodiak Airport

STATION: Existing Inlet

SHEET 1 **OF** 4

CULVERT DESIGN FORM

DESIGNER / DATE: RFG / 9/27/12

REVIEWER / DATE: B Spencer / 11/27/12

HYDROLOGICAL DATA

SEE ADD'L SHTS.

☒ METHOD: Comparison To Myrtle Creek

☐ DRAINAGE AREA: 4.0 ☐ STREAM SLOPE: 100 ft/mi

☐ CHANNEL SHAPE: Trapezoidal

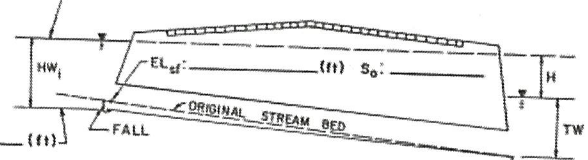
☐ ROUTING: N/A ☐ OTHER:

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)
10	990	3.6
100	1280	4.0

EL_{hd}: ______ (ft)

ROADWAY ELEVATION: 171.5 (ft)



EL_i: 163.1 (ft)

$S = S_o - FALL / L_a$

$S =$ 0.004

$L_a =$ 275'

EL_o: 162 (ft)

HEADWATER CALCULATIONS

CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	INLET CONTROL HW$_i$/D (2)	HW$_i$	FALL (3)	EL$_{hi}$ (4)	OUTLET CONTROL TW (5)	d_c	$\frac{d_c+D}{2}$	h_o (6)	k_e	H (7)	EL$_{ho}$ (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
2 - 6'x10' Concrete Box (100 yr)	1280	640	1.55	9.3	∅	172.4	4'	5	5.5	5.5	0.5	3.3	165.3	172.4	–	
(50 yr)	1190	595	1.4	8.4	∅	171.5	4'	4.7	5.4	5.4	0.5	2.9	164.9	171.5	–	
(25 yr)	1110	555	1.35	8.1	∅	171.2	3.8	4.5	5.3	5.3	0.5	2.4	164.4	171.2	–	
(10 yr)	990	495	1.2	7.2	∅	170.3	3.6	4.3	5.2	5.2	0.5	2.1	164.1	170.3	–	

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) $HW_i/D = HW/D$ OR HW_i/D FROM DESIGN CHARTS

(3) $FALL = HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_i + EL_i$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) $h_o = TW$ or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29n^2 L)/R^{1.33}\right] V^2/2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS:

a. APPROXIMATE
f. CULVERT FACE
hd. DESIGN HEADWATER
hi. HEADWATER IN INLET CONTROL
ho. HEADWATER IN OUTLET CONTROL
i. INLET CONTROL SECTION
o. OUTLET
sf. STREAMBED AT CULVERT FACE
tw. TAILWATER

COMMENTS / DISCUSSION:

Slope = $\frac{163.1 - 162}{275'}$ = .004 = 0.4% (culvert addition)

Tailwater based on 30' width @ 1% slope, n = 0.04

Increase roadway elevation as needed to pass design flow.

CULVERT BARREL SELECTED:

SIZE:

SHAPE: N/A

MATERIAL: Use Existing.

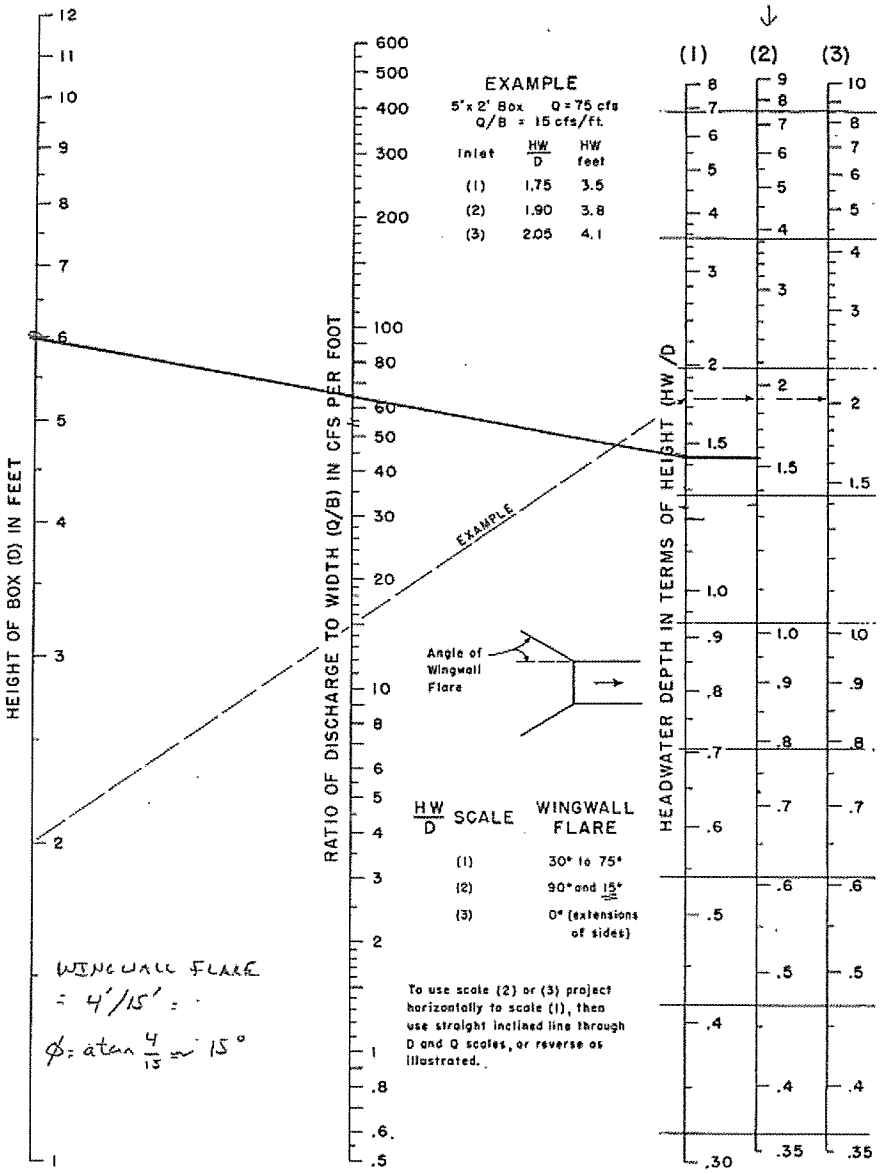
ENTRANCE:

240

10x6 Box

$\frac{Q}{B} = \frac{640 cfs}{10 ft} = 64 cfs/ft$ $\frac{H_w}{D} = 1.55$ $H_w = (1.55)(6) = 9.3$

CHART 8



BUREAU OF PUBLIC ROADS JAN. 1963

HEADWATER DEPTH FOR BOX CULVERTS WITH INLET CONTROL

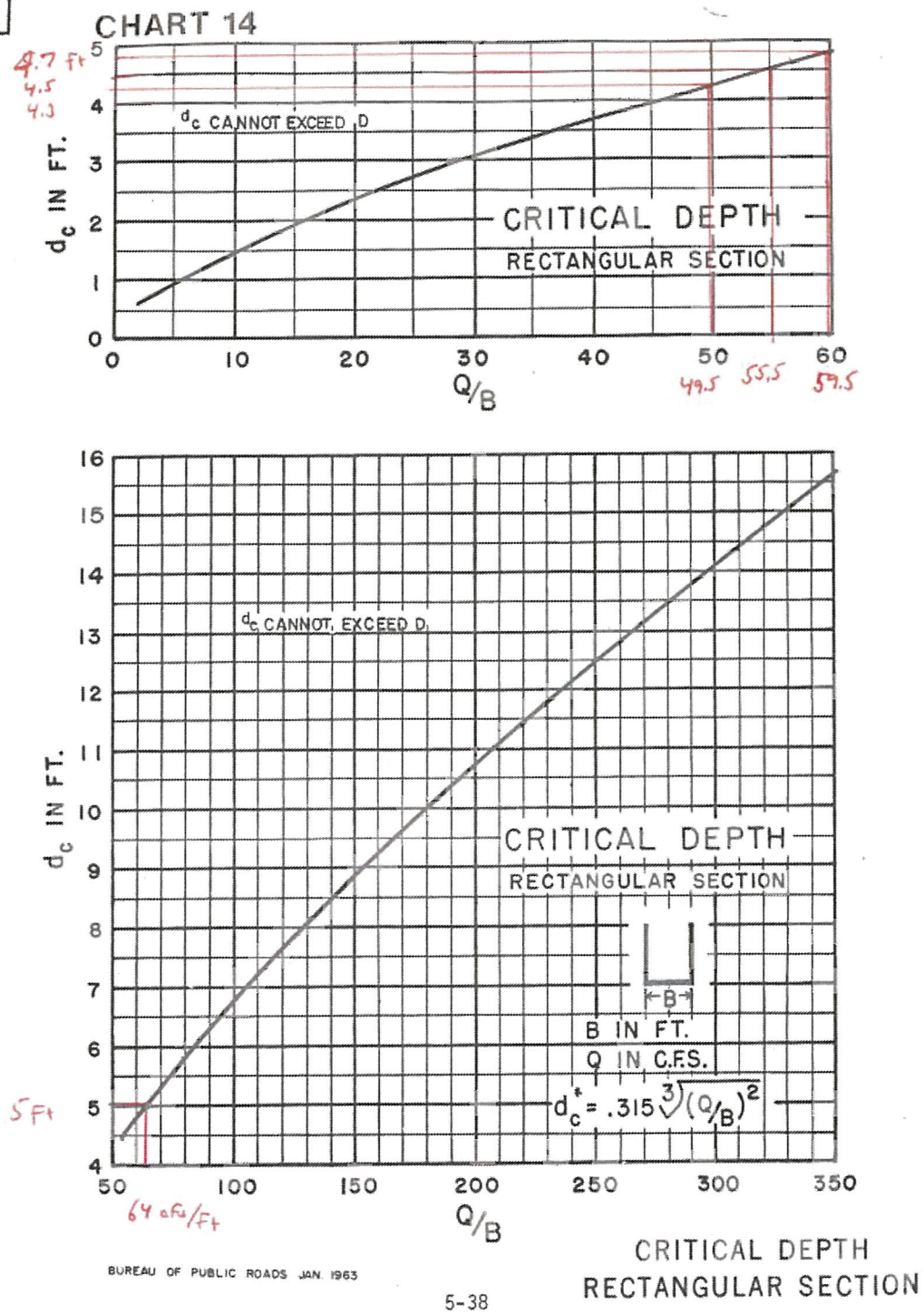
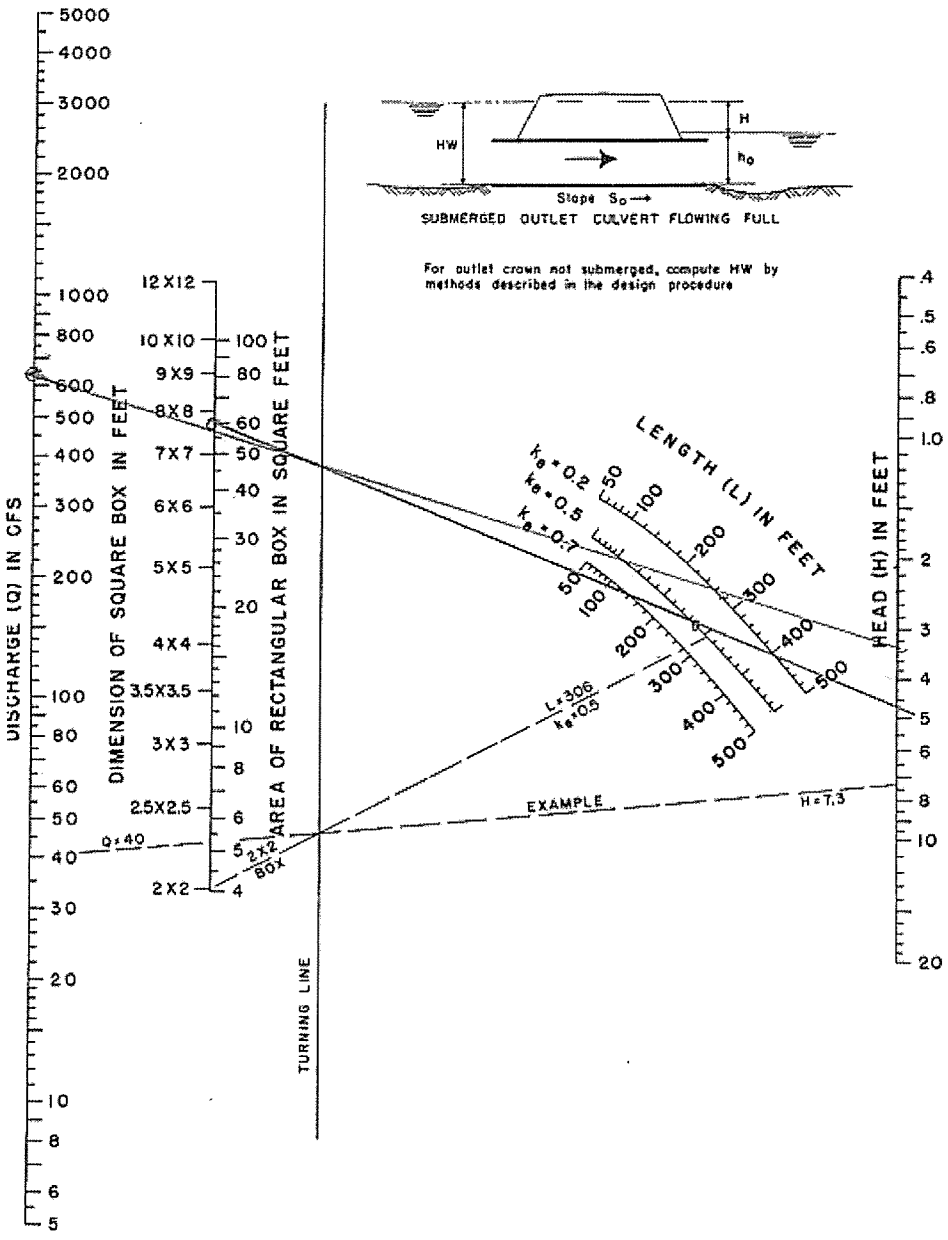


CHART 14
4.7 Ft
4.5
4.3
d_c CANNOT EXCEED D
d_c IN FT.
CRITICAL DEPTH
RECTANGULAR SECTION
Q/B
49.5
55.5
59.5
d_c CANNOT EXCEED D
d_c IN FT.
CRITICAL DEPTH
RECTANGULAR SECTION
B
B IN FT.
Q IN C.F.S.
$d_c^* = .315\sqrt[3]{(Q/B)^2}$
5 Ft
64 cfs/Ft
Q/B
BUREAU OF PUBLIC ROADS JAN. 1963
CRITICAL DEPTH
RECTANGULAR SECTION
5-38

CHART 15



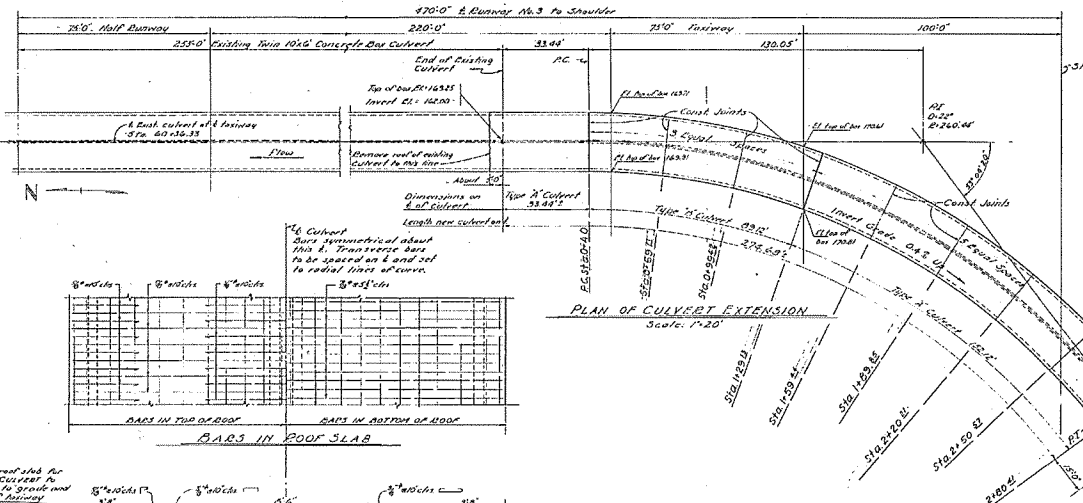
HEAD FOR
CONCRETE BOX CULVERTS
FLOWING FULL
n = 0.012

AU OF PUBLIC ROADS JAN. 1963

195

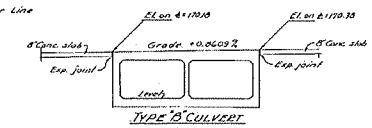
Appendix C

U.S. Naval Station, Kodiak, Culvert As-Built Drawing, Oct. 25, 1951



PLAN OF CULVERT EXTENSION
Scale: 1"=20'

BARS IN ROOF SLAB



TYPE 'B' CULVERT

SECTION ON ℄ OF TAXIWAY

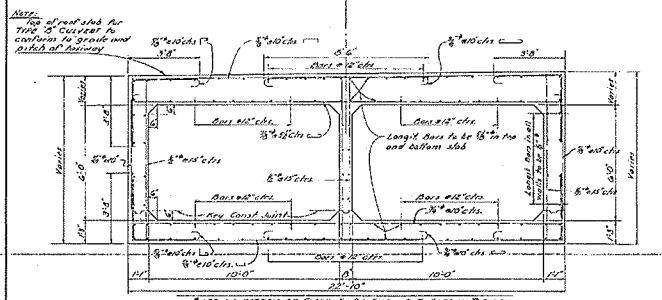
GENERAL NOTES

LOCATION OF STRUCTURE
Exact location and alignment of culvert extension to be determined in the field. Alignment to conform to present culvert and existing open ditch leading to timber culvert under road to south.
Grade through new extension to be uniform grade of 0.4%. Grade through old culvert is approximately 1.0%

ALTERATION TO INLET END OF OLD CULVERT
Remove all parts of old roof, side walls, center wall and floor that do not conform to the regular cross section. Rebuild, using exposed re-bars cleaned and bent into new construction and new rebars as required to provide a section similar to the TYPE 'A' culvert shown on this sheet (Sta. 8" dowels to tie old culvert into new extension.
All of the inlet structure including wing walls, footings, and paving shall be completely removed.

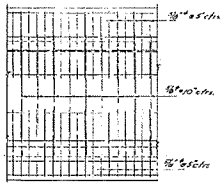
CULVERT SECTIONS
Type 'A' culvert shall be of uniform cross section to dimensions shown. Provide a minimum of 3" of earth cover on roof at inlet end.
Type 'B' culvert to have cross section similar to Type 'A' culvert except that the top surface of the roof slab shall conform to the grade and pitch of the taxiway. See sketch for grade on taxiway

SOIL PRESSURE
The maximum computed soil pressure is 1500 #/ft²

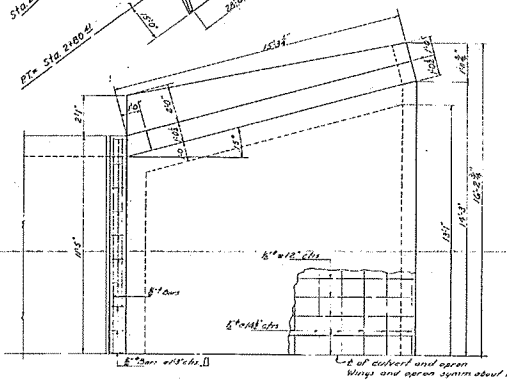


BARS IN BOTTOM OF FLOOR TO BE SIMILAR TO BARS IN TOP OF ROOF. BARS IN TOP OF FLOOR TO BE AS SHOWN

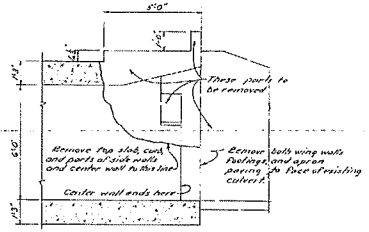
SECTION THRU TYPE 'B' CULVERT
SCALE ⅜"=1'-0"



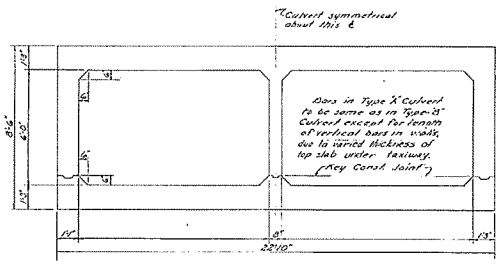
BARS IN OUTSIDE FACE OF WALL



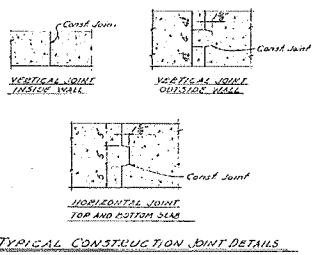
HALF PLAN



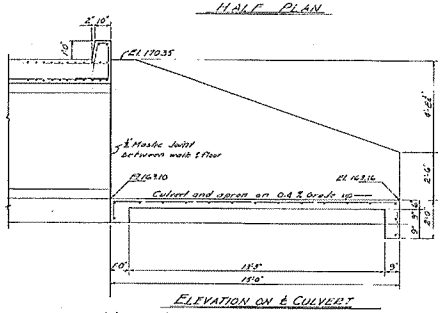
PART SECTION SHOWING EXISTING FRAMING AT INLET END OF OLD CULVERT



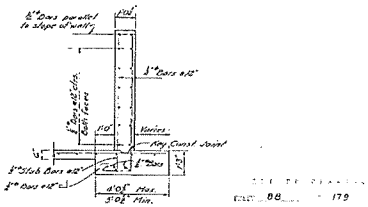
SECTION THRU TYPE 'A' CULVERT



TYPICAL CONSTRUCTION JOINT DETAILS



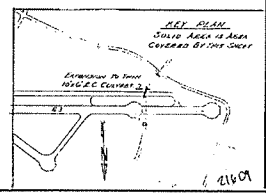
ELEVATION ON ℄ CULVERT
WING WALLS AND APRON AT INLET END OF CULVERT
Scale: ⅜"=1'-0"



TYPICAL WING SECTION

GRAPHIC SCALES

3/8"=1'-0" 0 6" 1' 2' 3' 4' 5' 10' 15'
1"=20'=0" 0 5' 10' 15' 20' 40' 60' 80' 100' 120'



REVISION	DATE	APPD.	DESCRIPTION	BY

ARCHITECTS JOB NO. 11867
ARCHITECTS DRAWING NO. 96
DES. J.S
DRWN. J.S TR. J.S
CHK. J.S.
SUPV. D.R.D
IN CHARGE D.R
BUREAU
CHK.
MGR.
PROJ. MGMT. N/A
DIRECTOR
APPROVED FOR
DATE 25 Oct 61

LEO A. DALY CO. ARCHITECTS-ENGINEERS
OMAHA, NEBR. ST. LOUIS, MO.

U.S. NAVAL STATION
KODIAK, ALASKA
TAXIWAY EXTENSION
REIN. CONCRETE TWIN 10'x6' BOX CULVERT
LEFT STA. 60+36.33

APPROVED
OFFICER IN CHARGE
DATE 25 Oct 61
BUREAU OF YARDS & DOCKS
FOR CHIEF OF BUREAU
SCALE AS SHOWN
SHEET 88 OF 179 NO. 26646
SPEC. 26687
Y&D DRAWING NO. 504248

95-45-3170
NA34/N1-9(29)