ALAN PLUMMER ASSOCIATES, INC.
ENVIRONMENTAL ENGINEERS AND SCIENTISTS

MEMORANDUM

MARTIN ROAD LAKE DRAINAGE MASTER PLAN
Piping Feasibility Analysis

Project No.: 0458-022-01

Date: 11/06/2013

Prepared For: City of Amarillo

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Background:

During the October 10, 2013 review meeting between the City of Amarillo and Alan Plummer Associates, Inc. (APAI), the City requested that a feasibility study be performed to evaluate the option of piping the flows at the four inlet locations on the western portion of Martin Road Lake. This memorandum will explain the process used to evaluate the four entry points (shown on the figure below), the conceptual cost estimates, and **APAI's** recommendation for the inlet points.

Figure No. 1

Sites 1, 2, and 3 have significant amounts of concrete rubble and debris that function as slope erosion protection at the mouth of each pipe. However, at sites 1 and 4, significant downstream erosion has occurred. Based on the City's drainage design criteria, the pipes under the roadway at sites 1 and 2 are considered culverts since they connect earthen channels north of NE 15th Street to earthen channels entering Martin Road Lake. According to the City's drainage criteria, culverts are to be designed to convey the 25-year peak flows. Sites 3 and 4 are considered part of the stormwater conveyance system. The City's drainage criteria, states that stormwater conveyance piping should be designed to convey the two-year peak flows.

APAI performed three tasks in response to the City's comments during the meeting:

> Task #1: Determine the capacity of the existing outfall pipes at the specified outfalls at Martin Road Lake.
>
> Task #2: Determine whether the existing outfall pipe sizes have sufficient capacity if they are extended to the toe of the lake.
>
> Task #3: Determine what size drainage swale above the pipe would be required to contain the flows from a 100-year storm event, as the pipes themselves are not sized to convey the 100-year flow.

Methodology and Findings:

Task #1 was to determine the capacity of the existing outfall pipes at the specified outfalls at Martin Road Lake and compare them to the HEC-HMS peak runoff flows for ultimate development conditions. APAI compared the two north outfalls (sites 1 and 2) to the 25-year event. The road should have 25-year protection as required by City criteria. APAI compared the two south outfalls (sites 3 and 4) to the two-year event because they are outfalls from the storm drain system per City criteria (see attachment no. 1). Based on the peak flows at full development changes to the existing culverts would have to be made. . Sites 1, 2, and 4 require significant upsizing to large culvert boxes. Site 3 requires that the existing CMP pipe be changed to a smoother pipe (higher n value).

Task #2 was to determine whether the existing outfall pipe sizes have sufficient capacity if they are extended to the toe of the lake. Extending these pipes allows for increasing the slope of the pipes, thereby increasing the pipe's capacity. The results were compared to the peak flows generated by HEC-HMS. Additional slope values were checked and provided to show the range of possible capacities in the pipe with each slope (see attachment no. 2). Based on these calculations several alternatives are available for use during the design phase of this project.

Task #3 was to determine the preliminary size of a drainage swale constructed above the pipes necessary to convey flows from a 100-year storm event, as the pipes themselves are not sized to convey the 100-year flows (see attachment no. 3). These swales would vary in size, but it would be necessary to keep the velocities of flow below 6 feet per second to control erosion, otherwise channel armoring will be necessary. Based on these calculations, several alternatives are available for use during the design phase of this project, and they will mainly be based on the combination of pipe capacity and swale size necessary to convey the design storm.

Attachment 3 shows that all four sites can convey the 100-year peak flow with a reasonably sized drainage swale using a slope from the existing drainage structure outfall to the lake's water surface. The southwest corner has the largest contributing drainage area and will thus require the largest swale (22-ft bottom width, 4:1 side slopes, 2-ft depth, and a 50-ft top width). APAI proposes that this swale be cut at a diagonal in the northeast direction from the outfall to the lake. This will help to avoid impacting the existing adjacent property owner to the existing dog-leg outfall channel. The other three sites will require significantly smaller drainage swales to convey the 100-year peak flows.

Additional evaluation during the design phase will be necessary to verify the design parameters of these piped systems and the cost implications of each option. Please see Attachments 1–3 and the Conceptual Engineering Construction Cost for details.

Conceptual ideas are also presented, should the City desire to extend each outfall to the lake's water surface. This will enable steeper slopes to be utilized, avoiding the larger, more costly drainage structures. With this alternative, the slope of the existing pipe under the road may still pose a capacity-driven bottleneck unless this slope can also be steepened. Attachment 2 shows that it is feasible for each outfall structure to convey the required peak flow using a steeper slope from the pipe outfall to the lake's typical water surface elevation. It may also be beneficial to have the pipe alignments offsite from the current channel to increase pipe embedment stability.

Cost Estimate:

Based on the necessary changes to the four outfall locations to meet City drainage criteria, a conceptual cost estimate was prepared and is attached to this memo. To identify the conceptual construction cost, it was assumed that the proposed pipe's slope matches the existing slopes of the four pipes entering the lake. The cost estimate also includes the upsizing of three of the four pipes (sites 1, 2, and 4), as these three are undersized. Site 3 will require the replacing of the CMP pipe to an RCP to meet capacity requirements. The conceptually estimated construction cost for the required upgrades and to pipe the flow to the lake edge is $1,200,000. This cost is conceptual and is not based on a City-approved approach. Several factors may increase or decrease the cost, including the slopes of the pipes, the level of service (if the City requires more conveyance that outlined in the current drainage manual), or if the Parks Department requires complete conveyance of the runoff in pipes.

Conclusion:

It is feasible to convey the runoff reaching each of these four sites by piping the flows to the lake. Additional evaluation is necessary during the preliminary design phase to clearly identify what the design parameters are and which area of the lake is more valuable to the Engineering and Park Departments in terms of future use and maintenance.

City of Amarillo
Martin Road Lake Outfall Piping Options
October 31, 2013
Sites 1, 2, 3, 4

Prepared by : George Farah, P.E.

Item	Item Description	Unit	Quantity	Unit Price	Amount
1	Unclassified Channel Excavation including All Removal Items such as Piping, Fencing, Trees, etc.	CY	3,472	$ 15	$ 52,083
2	Compacted Fill and Embankment	CY	1,111	$ 25	$ 27,778
3	36-inch Rock Rip-Rap	SY	500	$ 180	$ 90,000
4	Furnish & Install Erosion Control Blanket	SY	5,556	$ 3	$ 16,667
5	Design, Implementation & maintenance of Traffic Control Plan	LS	1	$ 12,000	$ 12,000
6	Design & Implementation of Trench Safety System	LF	1,310	$ 5	$ 6,550
7	48-inch RCP (Conceptual Sizing)	LF	250	$ 150	$ 37,500
8	8' x 4' RCB (Conceptual Sizing)	LF	350	$ 550	$ 192,500
9	7' x 4' RCB (Conceptual Sizing)	LF	310	$ 520	$ 161,200
10	5' x 4' RCB (Conceptual Sizing)	LF	400	$ 420	$ 168,000
11	8' x 4' FW-0 Concrete Headwall	EA	1	$ 20,000	$ 20,000
12	7' x 4' FW-0 Concrete Headwall	EA	1	$ 18,000	$ 18,000
13	5' x 4' FW-0 Concrete Headwall	EA	1	$ 15,000	$ 15,000
14	48" FW-0 Concrete Headwall	EA	1	$ 4,500	$ 4,500
15	Curb and gutter remove and replace	LF	220	$ 35	$ 7,700
16	Asphalt Pavement remove and replace	SY	333	$ 40	$ 13,333
17	Allowance for Irrigation Repairs	LS	1	$ 10,000	$ 10,000
	Subtotal				**$ 852,811**
				Contingency (40%)	**$ 341,124**
	Total Conceptual Opinion of Probable Construction Cost				**$ 1,193,936**

Notes:
1) Assumes no let down Chutes are included.
2) Assumes rock rip-rap is in Amarillo (or recycled concrete is used).
3) Assumes that there is are no additional mobilization or demobilization due to flooding.
4) Does not include any channel armoring for flow velocities greater than 6 ft. per second.

ALAN PLUMMER ASSOCIATES, INC.

ENVIRONMENTAL ENGINEERS AND SCIENTISTS

November 1, 2013

INPUTS PROPOSED

Constants:

0.012 n, concrete

0.024 n, corrugated metal

1.49 k, constant

Attachment 1 - Martin Road Lake: Existing Capacity of Culverts

Sites	Location	2-year Peak Flow (cfs)	25-year Peak Flow (cfs)	Elev. Upstream (ft) (plans)	Elev. Downstream (ft) (contours)	Distance (ft)	Slope (ft/ft)	Existing Culvert Section	Cross Sectional Area (sf)	Wetted Perimeter (ft)	Hydraulic Radius (ft)	Peak Flow (cfs), Manning's	Notes
1*	NW Corner		241.43	3,617.75	3617.72	96.78	0.0003	Existing 48" RCP	12.57	12.57	1.00	27.5	Barrell #1 of 2.
				3,617.60	3617.69	98.2	-0.0009	Existing 48" RCP	12.57	12.57	1.00	#NUM!	Barrell #2 of 2. Survey shows negative slope.
				3,617.75	3617.35	110	0.0036	Proposed 7'x4' RCB	28.00	22.00	1.27	246.2	Prop, Slightly adjusted downstream slope.
2*	NE Corner		153.04	3,618.89	3,618.66	75.00	0.0031	Existing 48" CMP	12.57	12.57	1.00	43.2	Different Manning's n-value.
				3,618.89	3,618.60	75.00	0.0039	Proposed 5'x4' RCB	20.00	18.00	1.11	165.7	Prop, Slightly adjusted downstream slope.
4**	SW Corner	449.37		3,617.41	3,617.38	15.12	0.0020	Existing 66" RCP	23.76	17.28	1.38	162.5	
				3,617.41	3,617.25	15.12	0.0106	Proposed 8'x4' RBC	32.00	24.00	1.33	495.1	Prop, Slightly adjusted downstream slope.
3**	S-SE Corner	63.12		3,619.30	3,617.81	465.00	0.0032	Existing 48" CMP	12.57	12.57	1.00	44.2	Survey calls this a 60" RCP, but plans show a 48".
				3,619.30	3,617.81	465.00	0.0032	Proposed 48" RCP	12.57	12.57	1.00	88.3	Give this pipe a smooth liner and it will meet capacity.

* Culverts should be designed so there is no overtopping of the associated road for the 25-year storm event (COA Storm Water Criteria Manual Section 7.2.1.)

** Storm sewer systems shall be designed for the 2-year event.

ALAN PLUMMER ASSOCIATES, INC.

ENVIRONMENTAL ENGINEERS AND SCIENTISTS

Novemeber 1, 2013

INPUTS Does not meet criteria.

Constants:

0.012 n, concrete

1.49 k, constant

Attachment 2 - Martin Road Lake: Sizing Culverts/Pipes

Drainage Area	Location	2-year Peak Flow (cfs)	25-year Peak Flow (cfs)	100-year Peak Flow (cfs)	Elev. Structure Exit (ft)	Elev. Downstream at Lake (ft)	Distance (ft)	Slope (ft/ft)	Existing Culvert Section	Cross Sectional Area (sf)	Wetted Perimeter (ft)	Hydraulic Radius (ft)	Peak Flow (cfs), Manning's	Notes
1*	NW Corner		241.43	338.39	3,617.72	3,614.00	276	0.0135	Existing 48" RCP	12.57	12.57	1.00	362.3	Existing Double Barrell Culvert, Existing slope from Existing Culvert to Water Surface
								0.0050	48" RCP	12.57	12.57	1.00	220.7	
								0.0100	48" RCP	12.57	12.57	1.00	312.1	
								0.0150	48" RCP	12.57	12.57	1.00	382.2	
								0.0200	48" RCP	12.57	12.57	1.00	441.3	
2*	NE Corner		153.04	215.86	3,618.66	3,614.00	342	0.0136	Existing 48" CMP***	12.57	12.57	1.00	182.1	Survey calls this a 60" RCP, but plans show a 48", Existing Slope from existing culvert to water surface
								0.0050	48" RCP	12.57	12.57	1.00	110.3	
								0.0100	48" RCP	12.57	12.57	1.00	156.0	
								0.0150	48" RCP	12.57	12.57	1.00	191.1	
								0.0200	48" RCP	12.57	12.57	1.00	220.7	
4**	SW Corner	449.37		1,177.35	3,617.38	3,614.00	308	0.0110	Existing 66" RCP	23.76	17.28	1.38	382.1	Attachment 1 - Martin Road Lake: Existing Capacity of Culverts
								0.0050	66" RCP	23.76	17.28	1.38	257.9	
								0.0100	66" RCP	23.76	17.28	1.38	364.8	
								0.0150	66" RCP	23.76	17.28	1.38	446.8	
								0.0200	66" RCP	23.76	17.28	1.38	515.9	
								0.0250	66" RCP	23.76	17.28	1.38	576.8	
								0.0300	66" RCP	23.76	17.28	1.38	631.8	
3**	S-SE Corner	63.12		161.55	3,617.81	3,614.00	142	0.0268	Existing 48" CMP***	12.57	12.57	1.00	255.6	Attachment 1 - Martin Road Lake: Existing Capacity of Culverts
								0.0050	48" RCP	12.57	12.57	1.00	110.3	
								0.0100	48" RCP	12.57	12.57	1.00	156.0	
								0.0150	48" RCP	12.57	12.57	1.00	191.1	
								0.0200	48" RCP	12.57	12.57	1.00	220.7	
								0.0250	48" RCP	12.57	12.57	1.00	246.7	
								0.0300	48" RCP	12.57	12.57	1.00	270.3	

* Culverts should be designed so there is no overtopping of the associated road for the 25-year storm event (COA Storm Water Criteria Manual Section 7.2.1.)

** Storm sewer systems shall be designed for the 2-year event.

*** Assume pipe extension to lake is concrete material.

ALAN PLUMMER ASSOCIATES, INC.
ENVIRONMENTAL ENGINEERS AND SCIENTISTS

November 1, 2013

INPUTS

Constants:

0.03 n, grass near lake

1.49 k, constant

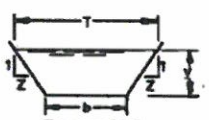
Attachment 3 - Martin Road Lake: Sizing Swales

Drainage Area	Location	2-year Peak Flow (cfs)	25-year Peak Flow (cfs)	100-year Peak Flow (cfs)	Elev. Structure Exit (ft)	Elev. Downstream at Lake (ft)	Distance (ft)	Slope (ft/ft)	Proposed Swale Section	b, bottom width	Z, side slope	y, depth	T, top width	Cross Sectional Area (sf)	Wetted Perimeter (ft)	Hydraulic Radius (ft)	Design, Channel Peak Flow (cfs), Manning's	Major - Minor Storm Event Peak Flow (cfs), Manning's	Notes
1*	NW Corner		241.43	338.39	3,617.72	3,614.00	276	0.0135	Trapezoidal	15	4	1.01	23.08	19.23	23.33	0.82	97.5	97.0	
2*	NE Corner		153.04	215.86	3,618.66	3,614.00	342	0.0136	Trapezoidal	6	4	1.2	15.6	12.96	15.90	0.82	65.6	62.8	
4**	SW Corner	449.37		1,177.35	3,617.38	3,614.00	308	0.0110	Trapezoidal	30	4	2.35	48.8	92.59	49.38	1.88	732.5	728.0	Cut swale at diagonal instead of current alignment
3**	S-SE Corner	63.12		161.55	3,617.81	3,614.00	142	0.0268	Trapezoidal	10	4	1.02	18.16	14.36	18.41	0.78	99.0	98.4	

* Culverts should be designed so there is no overtopping of the associated road for the 25-year storm event (COA Storm Water Criteria Manual Section 7.2.1.)
** Storm sewer systems shall be designed for the 2-year event.

From City of Amarillo Drainage Criteria Manual.

TABLE 6-1 Geometric Elements of Channel Sections

Section	Area A	Wetted Perimeter WP	Hydraulic Radius R	Top Width T
Rectangular	by	$b + 2y$	$\frac{by}{b + 2y}$	b
 Trapezoidal	$(b + Zy)y$	$b + 2y\sqrt{1 + Z^2}$	$\frac{(b + Zy)y}{b + 2y\sqrt{1 + Z^2}}$	$b + 2Zy$