

December 6, 2016



Continental Country Club Home Owners Association
2380 North Oakmont Drive
Flagstaff, Arizona 86004

Attn: Vicki Duncan
President

Re: **Preliminary Liner Alternatives Analysis**
Lake Elaine Restoration
Continental Country Club
Flagstaff, Arizona
Terracon Project No. 65165238

Dear Ms. Duncan:

At your request, Terracon Consultants, Inc. (Terracon) is submitting this letter regarding preliminary liner alternatives that are being considered for the Lake Elaine project as discussed during our project meeting of December 1, 2016. This letter provides concept level information with respect to lake liner alternatives, estimated construction costs, and an anticipated project schedule through completion of all currently planned phases of the project. It is important to understand that the information provided in this report is conceptual in nature and is being provided for preliminary planning purposes only. The liner alternatives discussed in the report, and the engineering cost estimates will be further refined as Phase 1 of this project is completed.

General Lake Liner Overview

We understand the original lake liner was constructed in 1972 and consisted of a 16-inch thick layer of compacted clay soils derived from the area of the lake. In 1979, a cavity developed at the bottom of the lake and the liner failed, consequentially draining the lake. After multiple prior investigations and recommendations from third-party engineering firms, we understand the lake was ultimately re-lined with a 20 mil polyvinyl chloride (PVC) liner in 1981. We understand that since installation of the liner in 1981, periods of declined lake levels and the development of cavities have resulted in damage requiring partial repairs to the existing PVC liner.

Lake Liner Alternatives

Based on the geologic conditions of the lake bed as determined by previous geotechnical explorations at Lake Elaine, the underlying geologic formation is karst limestone. As has been well documented in previous engineering reports, initial construction of Lake Elaine was completed using compacted clay soils derived from the site to form the original liner. As evidenced by the performance of the lake liner shortly after the initial filling, this soil liner did not



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Environmental



Facilities



Geotechnical



Materials

perform as an adequate seal for the lake resulting in excessive seepage. Based on information provided by the National Resource Conservation Service (NRCS), synthetic liners are the preferred liner method in karst geology.

Previous explorations indicate the limestone bedrock underlying the lake is highly fractured and contains solution cavities. Considering that soil and soil-modified liners do not have sufficient tensile strength to span the fractures and solution cavities that are known to exist below the lake and which could occur in the future, these systems are considered risk prone and would potentially require substantial future maintenance. As we have also previously discussed, there is the potential that there is already an insufficient quantity of clay soils in the lake bottom that could be used to support soil liners and for the cushion/cover that is necessary for geo-synthetic type liners. For these reasons, soil and soil-modified liners are not considered viable liner solutions for Lake Elaine, and have in fact been ruled out in previous engineering studies of the lake.

Considering the karst and highly fractured limestone geology underlying Lake Elaine, it is our professional opinion that any lake liner utilized to restore Lake Elaine should consist of a synthetic product with some amount of tensile strength that would be capable of spanning small cavities and fractures. It is our opinion that a soil based liner is not appropriate given the geology of the lake bed and the past performance of the original soil based liner system.

Based on the foregoing discussion, Terracon recommends the following three lake liner alternatives be considered on a preliminary basis for the project:

Lake Liner Alternatives		
Alternative	Description	Anticipated Seepage Performance
A. PVC Liner	This system would consist of a single layer polyvinyl chloride (PVC) geomembrane liner of either 30 or 40 mil thickness placed on prepared subgrade soil and covered by a layer of soil for UV protection.	60 gpad for 30 mil liner 45 gpad for 40 mil liner
B. RPP Liner	This system would consist of a single reinforced layer polypropylene geomembrane liner of either 36 or 45 mils in thickness placed on the prepared subgrade soils.	40 gpad for 36 mil liner 32 gpad for 45 mil liner
C. Geocomposite Liner	This system would consist of a primary RPP liner underlain by a geonet for seepage control underlain by a geosynthetic clay liner, all placed on compacted subgrade soil.	19 gpad

Exhibit 1 attached provides typical schematic cross-sections of each of the above alternatives that could be considered for future lake rehabilitation. Key elements in the construction of the above alternatives would include:

- Draining and refilling the lake upon completion of new liner installation;
- Fish salvaging and harvesting prior to fully draining the lake;
- Removal, processing, replacement and compaction of a minimum of 12-inches of existing subgrade soils; and,
- Placement of liner materials and protective soil cover.

Summary of Advantages/Disadvantages			
Criteria	Rehabilitation Alternatives		
	A	B	C
Liner System	PVC	RPP	Geocomposite System
Performance/Leakage Reduction	45 to 60 gpad	32 to 40 gpad	19 gpad
Life Expectancy ¹	40 to 50 years	25 to 40 years	40 to 50 years
Warranties ²	15 years	20 years	15 to 20 years
Quality of Installation	High	High	High
Maintenance ³	None	None	None
Estimated Costs ⁴	\$2,701,476	\$2,485,026	\$4,721,725

¹ The life expectancy of these systems could be shortened if there is some impact (disturbance) to the liner system or if there is some change in water quality/chemistry that would affect the permeability of the liner material.

² Installation of any of the liner alternatives would carry a minimum one year warranty on construction installation and workmanship. The other warranties would be product warranties from the manufacturer subject to being installed per the items discussed above.

³ Installation of the geocomposite system (Alternative C) would allow for the detection of leakage and the possibility of future maintenance as discussed above.

⁴ Based on a liner thickness of 40 mils and 45 mils for Alternatives A and B, respectively.

Repair Alternative

As we discussed during our project meeting, the HOA could consider a potential liner repair option versus full liner replacement. Although the existing liner is currently considered to be beyond its life expectancy, a repair alternative may be the most economically viable option at this time when considering initial costs only. Any partial repair option that would be implemented at this project should consider the potential for increased maintenance costs for the portion of the existing liner that is left in place. Expected future performance of this alternative would be difficult if not impossible to be determined because of the age of the existing liner.

For purposes of determining potential costs associated with a partial repair option we have considered installation of a new RPP liner down to an approximate elevation of 6,832 feet MSL at the upper perimeter of the lake, with a spliced connection to the existing liner either within an anchor trench or by some other means to be determined. For the reasons previously outlined in

this report, we do not consider either pure bentonite or bentonite modified soil as an option of this partial repair alternative.

For purposes of this alternatives analysis, we are considering this repair option as Alternative D. In the absence of our engineering evaluation which will be completed during Phase 1, we cannot comment on all advantages and disadvantages that would be expected with this alternative nor on the anticipated performance. However, in addition to reduced costs, this repair alternative would have the following advantages:

- The entire lake would not have to be drained;
- The existing fish in the lake would not have to be managed during the lake draining process; and,
- The repair could be completed in a shorter period of time than would be required for full liner construction.

Preliminary Cost Estimate

A preliminary estimate of probable initial project costs has been developed for each of the rehabilitation alternatives outlined in this report. These preliminary estimates of costs have been developed for initial budget considerations by the Continental Country Club HOA and comparison of the alternatives versus the benefits that might be achieved in implementation of any of the alternatives.

Identification of the key construction features associated with each identified alternative and estimated quantities of each construction element have been based in part on the geometric/volume data outlined in previous reports completed by others. Original construction plans for the lake were not provided for our review nor was any detailed survey work completed at the site to determine final quantities for design and construction. Therefore, actual quantities may be somewhat different and may vary from those listed in this report.

Unit costs for the recommended alternatives have been estimated based upon prevailing local prices, cost data obtained from RS Means Site Work Cost Data (2016), and experience with similar rehabilitation strategies. We have also obtained material and installation cost information from manufacturers and suppliers of the various liner materials. The unit costs were developed by estimating the cost of applicable portions of the work required for the particular scenario and for the unique preliminary recommendations developed for this project. Accordingly, these unit prices would not necessarily be applicable for extrapolation to other projects or other portions of the development.

Based on the qualifications of the estimated unit costs and the construction quantities as discussed above, estimates of probable initial construction costs have been determined for each of the rehabilitation alternatives and are shown on detailed spreadsheets, Exhibits 2 through 5

attached. The following table provides a summary of the estimated initial costs for implementation of each of the recommended rehabilitation alternatives for the lake:

Preliminary Estimate of Initial Project Costs		
Alternative	Liner Thickness	Total Estimated Costs
A	30 Mil	\$2,527,476
	40 Mil	\$2,701,476
B	36 Mil	\$2,311,026
	45 Mil	\$2,485,026
C	36 Mil	\$4,547,725
	45 Mil	\$4,721,725
D	36 Mil	\$1,825,231
	45 Mil	\$1,950,531

Please note that the estimated project costs reflect estimated unit costs based on current conditions and implementation of any of the alternatives at the present time. If the rehabilitation work is implemented in the future or a phased program of rehabilitation is undertaken over a number of years, projected budget requirements should be adjusted annually to account for inflation or other economic factors that would affect construction costs at those times.

Since Terracon has no control over the cost of labor, materials, equipment or services furnished by a potential contractor, a contractor's method of determining prices, or over competitive bidding or market conditions, the estimated probable costs provided in this report have been made on the basis of our experience and represents our best judgment as an experienced and qualified professional engineer, familiar with the construction industry. Additionally, at this level of evaluation, the quantities of the various repair and maintenance activities have been based on estimates using the information as previously discussed. No detailed survey to determine final bid quantities that would be used by a contractor have been made. Accordingly, the estimated quantities of rehabilitation alternatives and the estimated costs should be considered for preliminary budgeting purposes only. Terracon cannot and does not guarantee that proposals, bids or actual project or construction costs will not vary from the estimated values provided in this report.

Preliminary Project Schedule

We have prepared two projected schedules to complete the restoration of the liner system for Lake Elaine. Schedule I represents the time frame associated with completing each step sequentially. Schedule II represents the time frame that could be accomplished if multiple tasks are completed concurrently. Schedule II would carry the higher contingency costs considering a full evaluation of the lake bottom will not be accomplished before bid documents are prepared. An outline of each of the preliminary schedules is provided in the following table:

Preliminary Estimate of Project Schedule			
Task	Phase	Schedule I Completion Date	Schedule II Completion Date
Bid Documents	1 – Lake Draining	12/19/16	12/19/16
Pre-Bid Conference	1 – Lake Draining	1/9/17	1/9/17
Notice of Award	1 – Lake Draining	2/6/17	2/6/17
Notice to Proceed	1 – Lake Draining	2/22/17	2/22/17
Drain Lake Elaine	1 – Lake Draining	8/1/17	8/1/17
Assessment of Lake Bottom	1 – Lake Restoration	9/1/17	6/1/17
Engineering Analysis	1 – Lake Restoration	10/1/17	7/1/17
Bid Documents	2 – Lake Restoration	12/18/17	8/1/17
Pre-Bid Conference	2 – Lake Restoration	1/8/18	8/15/17
Notice of Award	2 – Lake Restoration	2/9/18	9/1/17
Notice to Proceed	2 – Lake Restoration	2/23/18	9/15/17
Liner Installation	2 – Lake Restoration	6/29/18	12/15/17
Fill Lake Elaine	2 – Lake Restoration	11/5/18	5/1/18

General Comments

The intent of this document is to provide a concept level outline of the alternatives, estimated costs, and estimated schedule to restore the Lake Elaine liner system. We understand that the Continental Country Club HOA will use this information for preliminary project planning. To that extent, the information contained in this document should only be used for preliminary planning purposes as the information will be updated and refined as the project progresses.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report, or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.

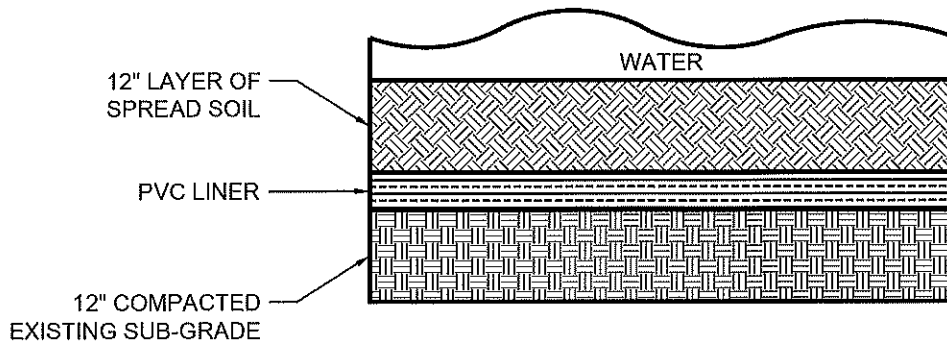
Jesse R. Huston, P.E.
 Senior Project Manager

Donald R. Clark, P.E.
 Senior Principal

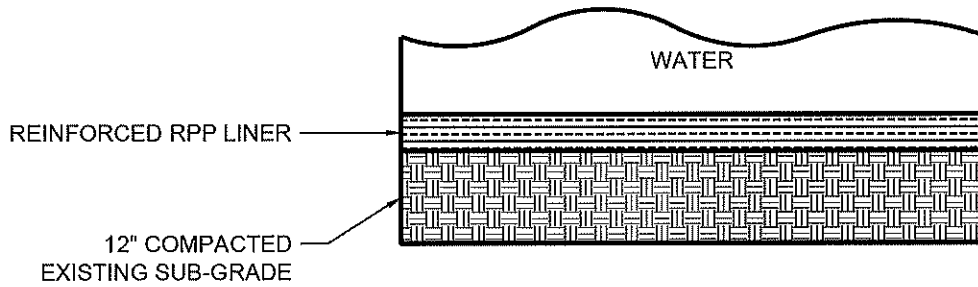
Attachments: Exhibit 1 – Alternatives A through C Cross Sections
 Exhibits 2 through 5 – Cost Analyses for Liner Replacement/Repair

Copies to: Addressee (1 via email)

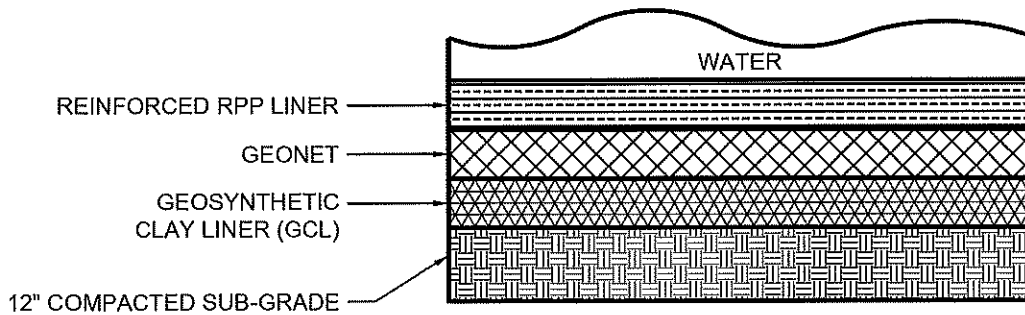
ALTERNATE A: PVC LINER




ALTERNATE B: RPP LINER



ALTERNATE C: RPP, GEONET LINER



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Project Mgr: JRH	Project No. 65165238	 Terracon Consulting Engineers and Scientists 4885 South Ash Avenue, Suite H-4 Tempe, AZ 85262 PH. (480) 897-8200 FAX. (480) 897-1133	ALTERNATIVES A THROUGH C CROSS SECTIONS	EXHIBIT
Drawn By: KLJ	Scale: NOT TO SCALE		Lake Elaine Alternatives Evaluation 2380 NORTH OAKMONT DRIVE FLAGSTAFF, ARIZONA	1
Checked By: JRH	File No. POND LINERS			
Approved By: DRC	Date: 11/30/2016			

Cost Analyses For Liner Replacement with PVC - Alternative A



Initial Data

PROJECT DATA

Client: Continental Country Club Home Owners Association
 Project Name: Lake Rehabilitation Alternatives
 Project No.: 65165238

Dawn Lake

DESCRIPTION OF WORK

DESCRIPTION OF WORK	Quantity	Units	Unit Cost	Cost
Drain Entire Lake of Water	50,000	1K gallons	1.5	\$75,000
Demolition of Existing Lake Wall	15,000	S.F.	1.55	\$23,250
Grading Above Shoreline	17,000	S.Y.	1.50	25,500
Compaction of Subgrade (12" Depth)	61,000	C.Y.	0.42	25,620
Materials & Installation Cost for Reinforced 30mil Liner	1,740,000	S.F.	0.45	783,000
Materials & Installation Cost for Reinforced 40mil Liner	1,740,000	S.F.	0.55	957,000
Placement of Imported Soil from Stockpile Onto Liner	61,000	C.Y.	12.00	732,000
Refill Lake Water	90,000	1K gallons	1.83	164,700
Engineering Costs				200,000
Contract Administration and Construction Observation				200,000
Contingency (Excluding Lake Drain/Refill)	@15%			298,406

TOTAL ESTIMATED COST WITH REINFORCED 30MIL LINER \$2,527,476

TOTAL ESTIMATED COST WITH REINFORCED 40MIL LINER \$2,701,476

Cost Analyses For Liner Replacement with RPP - Alternative B

Initial Data

PROJECT DATA

Client: Confidential Country Club Home Owners Association
 Project Name: Lake Rehabilitation Alternatives
 Project No.: 65165238

Dawn Lake

DESCRIPTION OF WORK

DESCRIPTION OF WORK	Quantity	Units	Unit Cost	Cost
Drain Entire Lake of Water	50,000	1K gallons	1.5	\$75,000
Demolition of Existing Lake Wall	15,000	S.F	1.55	\$23,250
Grading Above Shoreline	17,000	S.Y.	1.50	25,500
Compaction of Subgrade (12" Depth)	61,000	C.Y	0.42	25,620
Materials & Installation Cost for Reinforced 36mil Liner	1,740,000	S.F	0.80	1,392,000
Materials & Installation Cost for Reinforced 45mil Liner	1,740,000	S.F	0.90	1,566,000
Refill Lake Water	90,000	1K gallons	1.83	164,700
Engineering Costs				200,000
Contract Administration and Construction Observation				200,000
Contingency (Excluding Lake Drain/Refill)	@15%			279,956

TOTAL ESTIMATED COST WITH REINFORCED 36MIL LINER

\$2,311,026

TOTAL ESTIMATED COST WITH REINFORCED 45MIL LINER

\$2,485,026

Cost Analyses For RPP, Geonet, & GCL - Alternative C



Initial Data

PROJECT DATA

Client: Continental Country Club Home Owners Association
 Project Name: Lake Rehabilitation Alternatives
 Project No.: 65165238

Dawn Lake

DESCRIPTION OF WORK

DESCRIPTION OF WORK	Quantity	Units	Rate	Cost
Drain Entire Lake of Water	50,000	1K gallons	1.5	\$75,000
Demolition of Existing Lake Wall	15,000	S.F	1.55	\$23,250
Grading Above Shoreline	17,000	S.Y.	1.50	25,500
Compaction of Subgrade	61,000	C.Y	0.42	25,620
Materials & Installation Cost for Reinforced 36mil RPP Liner	1,740,000	S.F	0.80	1,392,000
Materials & Installation Cost for Reinforced 45mil RPP Liner	1,740,000	S.F	0.90	1,566,000
Materials and Installation for GCL Liner	1,740,000	S.F	0.60	1,044,000
Materials and Installation for Geonet	1,740,000	S.F	0.40	696,000
Shotcrete Reinforcement	65,200	S.F	0.73	47,596
Shotcrete Material and Placement	610	C.Y	176.00	107,360
Refill Lake Water	90,000	1K gallons	1.83	164,700
Engineering Costs				200,000
Contract Administration and Construction Observation				250,000
Contingency	@15%			571,699

TOTAL ESTIMATED COST WITH REINFORCED 36MIL LINER \$4,547,725

TOTAL ESTIMATED COST WITH REINFORCED 45MIL LINER \$4,721,725

Cost Analyses For Partial Repair with RPP - Alternative D



Initial Data

PROJECT DATA

Client	Confidential Country Club Home Owners Association
Project Name	Lake Rehabilitation Alternatives
Project No.	65165238

Dawn Lake

DESCRIPTION OF WORK

DESCRIPTION OF WORK	Quantity	Units	Unit Cost	Cost
Partially Drain Lake Water	40,000	1K gallons	1.5	\$60,000
Demolition of Existing Lake Wall	15,000	S.F.	1.55	\$23,250
Grading Above Shoreline	17,000	S.Y.	1.50	25,500
Compaction of Subgrade (12" Depth)	46,000	C.Y.	0.42	19,320
Materials & Installation Cost for Reinforced 36mil Liner	1,250,000	S.F.	0.80	1,000,000
Materials & Installation Cost for Reinforced 45mil Liner	1,250,000	S.F.	0.90	1,125,000
Refill Lake Water	75,000	1K gallons	1.83	137,250
Engineering Costs				200,000
Contract Administration and Construction Observation				200,000
Contingency (Excluding Lake Drain/Refill)	@15%			220,211

TOTAL ESTIMATED COST WITH REINFORCED 36MIL LINER

\$1,825,531

TOTAL ESTIMATED COST WITH REINFORCED 45MIL LINER

\$1,950,531