TO: James L. App, City Manager

FROM: Meg Williamson, Interim Director of Public Works

SUBJECT: 21st Street (Westside) Reservoir

DATE: March 2, 2004

NEEDS: For the City Council to direct staff regarding the future operation and function of the existing reservoir.

FACTS:

1. The 21st Street Reservoir was built in 1925. The original roof was replaced with a new roof consisting of wood trusses and a continuous exterior stem wall. That roof exists today. In October 1968, a project added pipe column supports at the center of the existing roof trusses to correct the sagging roof and repaired cracks in both the roof and the floor of the reservoir.

2. In early 2001, the City repaired damaged truss top chord elements at two locations. The existing timber truss roof appears to be structurally compromised and due for replacement.

3. The reservoirs southwest corner started leaking in the late 1980's, with leaked water apparent whenever the reservoir exceeded 18 feet tall. This seepage condition continues to be observed. Water was also noticed under the liner as early as the one-year warranty inspection, when the installer attributed this to condensation. Furthermore, during reservoir liner installation, the installer documented that the 2-3 inches of the concrete stem wall were "dirt", and the concrete was "soft with no indications of aggregate".

4. Staff was concerned regarding the unknown structural integrity issues with the 21st Street reservoir. The initial structural concern focused on the obviously poor condition of the roof structure. Upon further observation, it was determined that additional investigation is needed for the entire side and structure.

5. In November 2003, the City Council directed staff to prepare an evaluation study and present options for repairs that recognized the whole condition of the reservoir. Locating the leak(s) and determining the structural integrity of the reservoir required several initial investigative steps including a dive inspection, geotechnical evaluations and structural element analysis. Attached are copies of these reports.

ANALYSIS AND CONCLUSION: The investigative process consisted of several issues that needed to be analyzed:

- The condition of the existing membrane lining and its water tightness
- The 1-1/2 inch concrete lining support slab
- The inlet/outlet piping
- The retrofitted perimeter wall that was added in the 1930's.

PVC observation pipes were installed and used to monitor the outside groundwater table elevation (natural groundwater outside the reservoir was known not to exist). The identification of outside groundwater adjacent to the reservoir initiated the recommendation to have the interior liner inspected. This recommended inspection, performed by an underwater diver, led to the discovery of approximately five locations where the HDPE liner had failed, which accounted for the reservoir leakage and the identification of both past and current intermittent saturated soil outside the reservoir. It was estimated that total water loss was approximately 5 gallons per minute. A temporary patch material was applied to prevent continued leaking until a permanent fix is implemented. In addition, the underwater inspection found that the inlet/outlets were in poor condition and required repair. Sediment fills the side inlet/outlets approximately 33% on the east side and approximately 25% on the west side. The sediment appears to consist primarily of gunite that has flaked from interior walls of the inlet/outlets. The concrete perimeter wall was tested for strength for potential use as a new bearing wall for a new roof. From the concrete tests performed, it was determined that the existing perimeter wall concrete exhibited less than required capacity needed to act as a continuous fully loaded supporting element. The perimeter stem wall would need to be removed and replaced to permit full use of the reservoir volume.

It will cost approximately $1.7 million dollars to repair and replace the roof, the membrane liner, the concrete liner, and the inlet/outlet pipes. Once repaired, the City will still have a reservoir that is over 80 years old with additional repairs that may be needed in the future.

As an option, the City Council could consider replacing the old reservoir with a new 4 million gallon tank with the opportunity of constructing a second 4 million gallon tank at the site. Both tanks would be designed and built to current seismic code and would expand the City's storage capacity to 8 million gallons at this site.

Two types of tanks could be considered: steel tank or a pre-stressed concrete tank. A steel tank would have an initial cost of $2.32 million dollars, while that of a concrete tank would be $2.84 million dollars. However, after performing a life-cycle cost analysis, the concrete tank would have a new present value of $2.85 million dollars, while the steel tank's new present value would be $3.08 million. The steel tank maintenance costs over the years would be more than the concrete tank. In addition, the concrete tank can be buried such that its visibility can be equal to or less than what currently exists with the old reservoir.

Staff requests that the City Council determine that the most cost-effective action regarding the future and operation of the existing reservoir is for its demolition and that a new 4 million gallon reservoir be designed for construction. Further, that the design should include the possibility of constructing a second 4 million gallon tank at this location.

POLICY REFERENCE: Water Operations and Maintenance.

FISCAL IMPACT: Cost to replace the old tank will be funded from the Water Operations Fund. The un-restricted net assets for the Water Operations Fund have a balance of $14 million dollars for the project.

OPTIONS:

A. For the City Council to determine that the existing 21st Street reservoir has reached the end of its life service and direct staff to initiate steps to design and construct two new 4 million gallon concrete tanks at this location.

B. Amend, modify, or reject the above option.

Attachment:
Report

Report Prepared By:
Ditas Esperanza, P.E.
Capital Projects Engineer

Project Status
21st Street Reservoir Roof Replacement

City of Paso Robles
Submitted To: Ditas Esperanza
City Engineer

Boyle Engineering Corporation

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Project Manager

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Project Status
21st Street Reservoir Roof Replacement

This report presents the overall status of the 21st Street Reservoir roof replacement project. Included in this report are discussions of recently identified issues that are considered critical to the future operation and function of the reservoir, and likely to influence decisions regarding replacement of the roof structure. These issues include (1) the condition of the existing membrane lining and its watertightness, (2) the 1-1/2-inch concrete lining support slab, (3) the inlet/outlet piping, and (4) the retrofitted perimeter concrete wall added in the 1930s. The four issues identified above were neither a portion of the recently developed roof replacement project nor a cognizant factor in the development of the scope of work for the roof replacement project; however, at this time, they have been recommended for evaluation and are to become a part of the overall roof replacement concept and evaluation. The following outlined discussion presents the status of the roof replacement project, including the influencing issues described above, in a chronological sequence of development:

The design of the new roof framing and covering were based upon criteria which specified: (a) the layout and configuration of the new roof framing and covering were to be similar in appearance to the existing deteriorated wood truss system; (b) accommodate interior access over the water surface for cleaning and observation; and (c) the new trusses were to be 10 to 12 feet in depth and supported on the existing columns and perimeter wall similar to the existing wood truss roof system. The construction documents presented a design that accommodated the above criteria, which exerted limited loads to the perimeter walls in order to not increase loads imposed by the existing wood truss framing. In other words, the new design utilized the existing perimeter wall for vertical loads and required replacement of the existing center columns to carry the seismic loading. The new trusses were to be of low-maintenance material, which would minimize the need for future maintenance repainting, and resistant to the corrosive nature of the atmosphere present over chlorinated stored reservoir water. Therefore, the trusses and support columns specified were to be of stainless steel, considered to be somewhat more expensive than mild steel (±10 percent), yet provide the benefit of lower overall costs for maintenance repainting in the future. The design and preparation of the construction documents for the reservoir roof replacement were completed and issued for construction bidding. The estimated opinion of construction cost for the replacement roof was developed and evaluated relative to current construction costs for similar work. At the bid opening, only one bid was received which was exorbitantly high and over the project estimated cost. Therefore, the single high bid was rejected.

Following the bid rejection Boyle began evaluating an alternative roof scenario. This scenario would not meet all the initial design criteria, but was to provide a simplified design alternative. Specifically, the alternative roof cover that was being considered was a low profile roof frame as opposed to the deep truss, would eliminate the refurbishment of the interior center columns, and use the existing perimeter wall as a primary load-bearing support element. The revised use and load demand on the perimeter wall necessitated the wall to be structurally evaluated for both its lateral and vertical capacities. In support of the perimeter wall's use as a major load-bearing element, the need for determining vertical and lateral soil bearing capacities around the perimeter of the reservoir was identified. While this alternative roof replacement scenario was being initiated, information was made available concerning the condition of the reservoir's interior lining, supporting concrete slab, and periodic moisture-saturated soil adjacent to a portion of the reservoir perimeter wall. It was then determined that if the soil-bearing capacities for the perimeter wall were to be determined in the field by a geotechnical engineer, this engineer should at the same time investigate the cause for the saturated soil or reservoir leakage adjacent to the perimeter ringwall. Therefore, a program was instigated to determine the needed soil-bearing capacities and to evaluate the presence of water in the ground adjacent to the perimeter wall.

PVC observation pipes were installed in the boreholes and used to monitor the outside groundwater table elevation (natural groundwater outside the reservoir was known not to exist). The identification of outside groundwater adjacent to the reservoir initiated the recommendation to have the interior liner inspected. This recommended inspection, performed by an underwater diver, led to the discovery of approximately five locations where the HDPE liner had failed, which accounted for the reservoir leakage and the identification of both past and current intermittent saturated soil outside the reservoir. It was estimated that total water loss was approximately 5 gallons per minute. A temporary patch material was applied to prevent continued leaking until a permanent fix is implemented. In addition, the underwater inspection found that the inlet/outlets were in poor condition and require repair. Sediment fills the side inlet/outlets approximately 33% on the east site and approximately 25% on the west side. The sediment appears to consist primarily of gunite that has flaked from interior walls of the inlet/outlets.

At the same time evaluations were being conducted for the perimeter wall soil bearing capacity and liner leakage, the concrete perimeter wall was tested for strength for potential use as a new bearing wall. From the concrete tests performed, it was determined that the existing perimeter wall concrete exhibited less than required capacity needed to act as a continuous fully loaded supporting element. Furthermore, Boyle recommends that the water level in the reservoir not exceed ground level.

As a result of information obtained relative to the past reservoir performance and physical condition, it was determined that the next task for development of an alternative roof cover replacement project should include a broad evaluation of reservoir reconditioning relative to its overall future performance and reliability based on facts and conditions now realized. This alternative roof cover system does not utilize the existing perimeter wall or center columns and would minimize the overall retrofit costs based on deficiencies identified above. The replacement and retrofit items are outlined in the following discussion:

a. Roof Replacement Type: Clear span low profile roof similar to a prefabricated metal building system. Access to the reservoir would be through roof-mounted access hatches with safety ladders to the reservoir bottom.

   The wall framing would consist of 8- to 10-foot-high panels mounted on short side wall columns. The foundation for the roof/wall framing would be by drilled pile/columns immediately adjacent to, but not bearing on the perimeter wall.

b. Parameter Stem Wall: Remove and replace existing parameter stem wall to permit full use of reservoir volume.

b. Interior Membrane Liner: Following the removal of the interior columns and footing, the liner will be closely evaluated and repaired or replaced as needed.

c. Interior Liner Support Slab: It is assumed the repairs will be required on the liner support slab. The full extent of the repairs will not be known until the reservoir is drained and the existing HDPE liner is removed. For estimating purposes, it is assumed that repairs are possible and would be required on 50% of the reservoir below grade.

d. <u>Inlet/Outlet Piping and Valves</u>: Replace existing gunite inlet/outlet system with steel pipe and flexible couplings.

As an alternative to the clear span roof system that utilizes the existing semi-buried reservoir and perimeter wall, a new 4-million-gallon circular tank was evaluated. This tank, either steel or prestressed concrete, would be placed in an area currently occupied by the east half of the existing reservoir allowing for a second 4-million-gallon tank to be erected in the future. The new tank would have a bottom elevation set at approximately one-half of the depth of the existing reservoir. Existing site material would be used to raise the existing reservoir bottom grade. The exposed cut area would be left exposed with the new top of berm used to partially shield the new steel tank from view.

Outlined below is a preliminary costs comparison of the project alternatives. The estimate is intended for a relative comparison, and will be revised once a specific alternative is selected.

a. Low Rise and Single Clear Span:

(1) Roof Demolition	$150,000	
(2) Remove / Replace HDPE Liner	$175,000	
(3) Repair Concrete Liner	$135,000	
(4) Piles @ 25' O/C	$26,000	
(5) Grade Beam	$42,000	
(6) Stem Wall	$110,000	
(6) New Metal Roof	$375,000	
(7) New Inlets Outlets (Including Valves / Piping / Fittings)	$143,000	
Subtotal		1,156,000
(8) Contingency 25%	$289,000	
(9) Contractors O&P 15%	$217,000	
Total		$1,662,000

b. New Steel Tank Alternative:

(1) 4MG Welded Steel Reservoir	$1,200,000	
(2) Earthwork	$56,000	
(3) Demolition of Existing Reservoir	$200,000	
(4) 12-Inch Gravel Pad	$24,000	
(5) Ringwall	$46,000	
(6) Valves / Piping / Fittings	$90,000	
Subtotal		$1,616,000
(7) Contingency 25%	$404,000	
(8) Contractors O&P 15%	$303,000	
Total		$2,323,000

c. New Prestressed Partially Buried Concrete Reservoir:

(1) 4MG Prestressed Reservoir	$1,600,000	
(2) Earthwork	$53,000	
(3) Demolition of Existing Reservoir	$200,000	
(4) Subgrade Preparation	$30,000	
(5) Valves / Piping / Fittings	$90,000	
Sub Total		$1,973,000
(6) Contingency 25%	$493,000	
(7) Contractors O&P 15%	$370,000	
Total		$2,836,000

Lifecycle Costs of Prestressed Vs. Steel Reservoir:

The lifecycle cost comparison below assumes a 15-year maintenance period between steel tank re-coatings. Based on recent bids for steel tank recoating, a coating cost of $6/ft^2 for interior surfaces and $3/ft^2 for exterior surface was assumed. It is estimated that the concrete reservoir will require $5,000 worth of joint sealant repair every 15-years.

Steel tank surface area assumptions:

Tank Capacity	4MG
Diameter	130 ft
Shell Height	40 ft
Wall Area	16,336 ft^2
Floor and Roof Area	13,273 ft^2
Total Interior	**42,882 ft^2**
Total Exterior	**29,609 ft^2**
Total Recoating Cost	**$316,510**

	Cost	*Year 15*	*Year 30*	*Year 45*	*Year 60*	*Total Lifecycle Cost (NPV)*[1]
Steel	$2,323,000	$493,112	$768,253	$1,196,913	$1,864,751	$3,080,992
PC	$2,836,000	$7,790	$12,136	$18,908	$29,458	$2,847,974

1. NPV calculations assume a 3% inflation rate and 4.5% discount rate (based on the 30-yr T-Bond)

The higher initial capital investment of the prestressed concrete reservoir is offset by the minimal maintenance requirements when compared to the welded steel. A Concrete reservoir provides the option of burying or partially burying the reservoir, mitigating visual impacts. In addition, the prestressed concrete reservoirs have proven track record of exceptional seismic performance.

It is the opinion of Boyle that the replacement of the existing reservoir will prove the lowest cost alternative in the long run. Considering the existing reservoir is over 80 years old, even with repairs as outlined above, additional repair work should be anticipated. A new tank will be designed and built to current seismic codes, provide the city with the option of adding an additional reservoir on the existing site (expanding total storage on the existing site to approximately 8 million gallons), and would increase the overall system reliability.

In addition to the external wall cracking, piping appears to be askew (#6). Of the two pipes present on the South side, the East pipe is more dramatically bent. It is not known to this inspector as to when this occurred or if it has always been like this.

The general appearance of the roof exterior is good. The roof was not part of the scope of work and was not thoroughly examined at this date.

12-21) After a thorough evaluation of the internal liner, five leaks were discovered in the visual range. Three were located in the West cell and two in the East. These leaks are numbered on the reference diagram included at the end of the report.

Of the five leaks located, referring to the diagram at the end of the report, the following is a list in the order of severity:

- Leak #1 - Highest flow - 2-3 G.P.M. estimated
- Leak #3 - Slight to moderate flow - 1 G.P.M. estimated
- Leak #4 - Slight to moderate flow - 1 G.P.M. estimated
- Leak #4 - Slight flow - Less than .25 G.P.M. estimated
- Leak #5 - Slight flow - Less than .25 G.P.M. estimated

In the report:

- Leak #1 is seen in photographs (#12-15);
- Leak #3 is seen in photograph (#16);
- Leak #5 is seen in photographs (#17-18);
- Leak #4 is seen in photographs (#19-21);
- Leak #2 is seen in included video.

All but one of the leaks were related to liner weld seams. The one leak not related to weld seams was a loose mechanical liner repair. Total water loss was estimated in the range of 5 G.P.M. Patch material was applied to all leak sites at the end of the inspection.

22-28) All exposed steel of the columns is rated as having an extremely poor coating condition. Since the number of rust tubercles is extensive, not all could be checked. Deep pits are strongly suspected. Liner connections to the columns appear stable and in good condition.

29-31) The concrete columns appear to be stable and in good condition. Liner connections to the columns appear to be in good condition.

32-34) The inlet/outlet openings are clear in both cases. Screens are properly attached and in good condition.

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SUMMARY

21'ST STREET RESERVOIR

GALLONS	4.00 MG	CONCRETE TANK	-	PREDOMINATELY BURIED
		ROOF	-	WOOD
		COLUMNS	-	CONCRETE & STEEL
		WALLS	-	LINED
		FLOOR	-	LINED
		SECONDARY USAGE	-	NONE

EXTERIOR WALLS	-	Predominately buried - Several vertical cracks are present around the circumference.
EXTERIOR ROOF	-	Appearances are good - not inspected.
INTERIOR ROOF	-	Appearances are good - not inspected.
ABOVE WALLS	-	All interior wall surfaces was submerged.
BELOW WALLS	-	Five leaks were seen in the liner. All but one were related to liner weld seams. The one leak not related to weld seams was a loose mechanical liner repair. Total water loss is estimated in the range of 5 G.P.M. Patch material was applied to all leak sites at the end of the inspection.
FLOOR	-	Good
SEDIMENT	-	1/4" deep
UNDERDRAIN	-	Not located
FLOAT	-	None
INLET	-	West side - slight sediment at the base of the pipe
Screen	-	Good
VAULT	-	No notable defects were sighted.
INLET	-	East side - sediment fills the pipe to 1/3 at the gunite to pipe connector.
Screen	-	Good
VAULT	-	No notable defects were sighted.

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OUTLET	-	Same as in inlet
DRAIN	-	Same as the inlet
COLUMNS	-	Concrete appear stable and in good condition. Steel - poor - deep pitting is suspected.
HATCH	-	Securely locked - located on the North wall,
LADDER	-	None

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RECOMMENDATIONS

1) In relation to the liner material itself, its condition is rated as overall good. All leaks, but one, were found in weld seams. The one exception was related to mechanical damage and not material failure. Leakage sites were patched and gross leakage is not suspected at this time. Keep water levels three feet below the top of the slope to remove the impact on most of the tank patches and apparently most sensitive areas.

2) In relation to the tank condition, if the decision is to repair or replace, this inspector would recommend replacement. The following is the logic scheme used:
   a) The tank is over 80 years old and has signs of wall tilting, wall cracking, as skewed piping indicating stress;
   b) The liner was installed, presumably because the tank had too many crack/leak problems to repair;
   c) Steel columns are in poor condition;
   d) Steel piping is old and inaccessible;
   e) It is unlikely that this tank is up to current seismic codes.

If the tank is repaired, a significant expenditure will only produce a repaired, old tank likely to have future substantial problems unless the re-work is very extensive.

The cost of repair should be considered against the cost of replacement. A new tank will be built to proper seismic codes, with new valving and pipes, as well as an underdrain to monitor water loss/leakage. It should also have a long, trouble free life.

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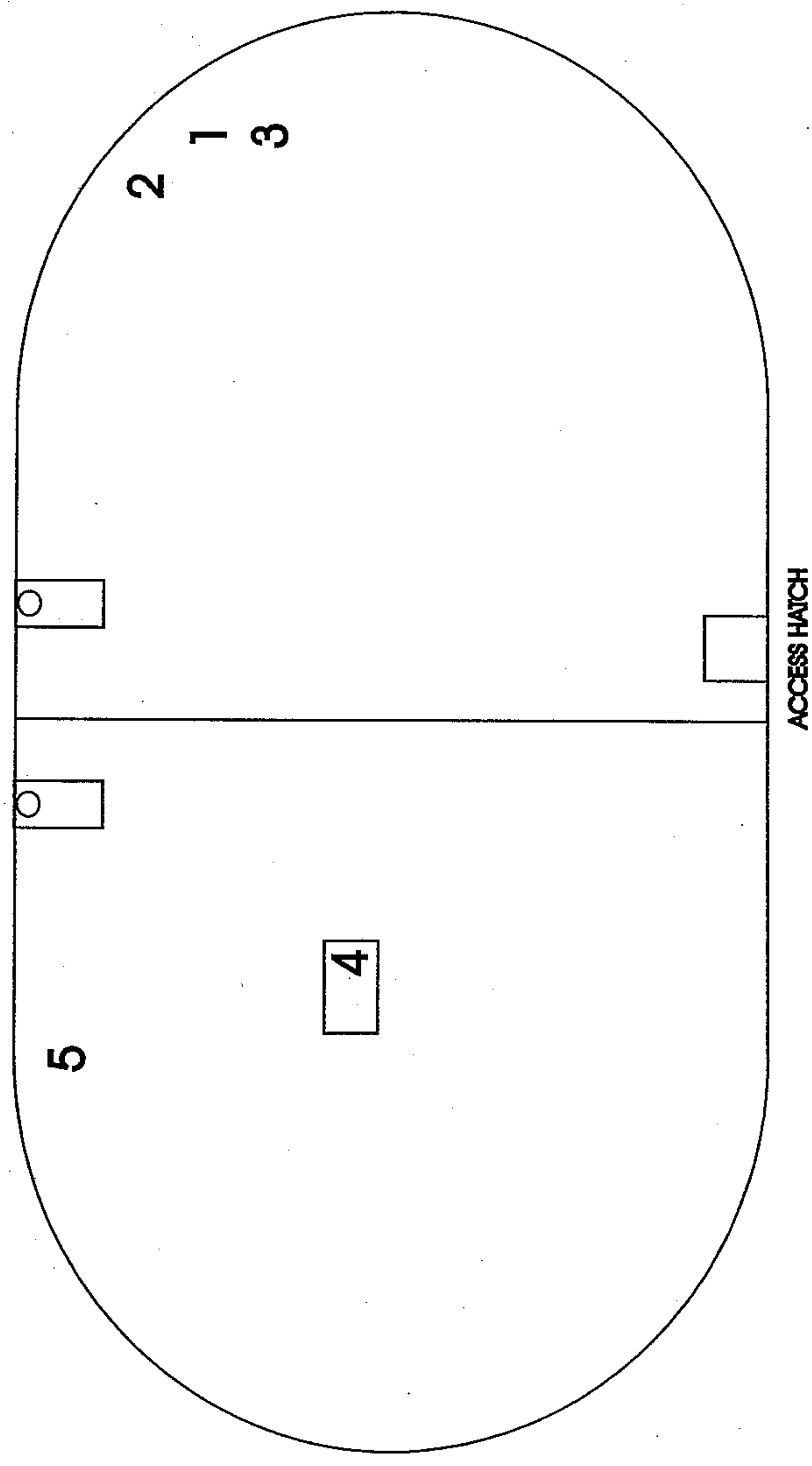

21'ST STREET RESERVOIR
CITY OF PASO ROBLES