DATE: April 11, 2014

TO: Duffy Price, President, Los Altos Hills County Fire District

FROM: Patrick Walter, Purissima Hills Water District

SUBJECT: To develop recommendations and cost analysis for seismic retrofit and/or expansion capacity of PHWD's Page Mill Zone 4 tank.

COMMITTEE MEMBERS: Patrick Walter (PHWD General Manager), Stu Farwell (LAHCFD Consultant), Gary Waldeck (LAHCFD Commissioner), John Justice (Deputy Chief), Jitze Couperus (Public Member) Joubin Pakpour (District Engineer)

BACKGROUND: Preliminary analysis of the Page Mill Tank conducted by the Purissima Hills Water District's (Water District) structural engineer in 2009 indicated the Page Mill tank either needed to be seismically retrofitted or rebuilt to withstand a moderate earthquake. The tank is 25 feet high and has a diameter of 60 feet, with an overflow located at 24 feet. In 2010, the Los Altos Hills County Fire District (Fire District) approached the Water District to examine the feasibility of expanding the Page Mill Tank, which is the sole source of water for Zone 4. At the Fire District's March 18, 2014 meeting, a presentation was given by the Water District to provide the results of a study to replace the existing 500,000 gallon Page Mill Tank with a larger 900,000 gallon tank to provide additional water storage in the Water District's highest Zone 4. The budget, originally estimated a $2 million in the 2011 down economy, has increase to $4 million. Alternatively, the Page Mill Tank could be retrofit, similar to the Neary Tank that is currently in construction. The current estimate for the retrofit work is $800,000. The Fire District formed an Ad Hoc Committee to study the merits of both alternatives.

AD HOC COMMITTEE: On March 25, 2014, the Ad Hoc committee met at the Water District's office. Stu Farwell was ill and not able to make the meeting. Joubin started meeting by explaining the retrofits needed to bring the existing Page Mill Tank to current seismic code standards for essential structures.

1 Enlarge the existing ring foundation from 12" by 18" to 24" by 36"
2 Anchor the tank to the foundation by welding connections to the tank that will accommodate anchor bolts embed in the new foundation
3 Weld rafter supports to reinforce the rafters
4 Strengthen rafter connection to shell of the tank
5 Eliminate the two solid connection points to the tank, overflow and drain
6 Remove the existing interior coating and repaint

The committee then discussed the need for additional water requirements for fire fighting. John explained that in a wild fire situation, additional water would not be needed due to the rapid movement of the fire. He also explained the existing tank was adequate for a typical house fire (1500 gallons per minute for two hours or 180,000 gallons). In addition, new houses being built all have fire sprinklers. The area is mostly developed, so there will not be an influx of new housing in the zone that currently serves 272 homes. Patrick explained that a larger zone 4 tank would not be used to fortify the lower zones by back feeding water, unless there was a short term low pressure situation. Also, due to the normal

cycling of the tank during the summer, a larger tank would store between 670,000 and 825,000 gallons compared to 320,000 and 420,000 gallons of the existing tank. The committee agreed that a 900,000 gallon tank would not be an efficient use of $4,000,000.

The committee agreed that seismic improvements should be constructed on the existing Page Mill tank, primarily for survival in an earthquake at an estimated cost of $800,000. While City of Palo Alto has three tanks above the Page Mill tank, there is no guarantee that their tanks will survive or have adequate water to provide PHWD water system after a seismic event.

A comprehensive seismic report on the Page Mill Tank completed last month for the Water District presented three scenarios based on water levels in the tank at the time of a major earthquake.

Scenario 1 indicated that if water in the tank is kept under the height of 15 feet to allow room for the water to slosh in an earthquake, virtually no damage would occur due to reduced water forces. This scenario called for eliminating the inflexible connections to the tank and maintenance of the failed steel and paint. Under this scenario, in summer conditions the tank would have between 225,000 gallons and 320,000 gallons. This is enough water for day to day operations for serving the 272 connections in the zone. There is risk of a catastrophic tank failure should an earthquake occur when the water level exceeds 15 feet. The estimated cost for these upgrades is up to $300,000 for design and construction depending on the condition of the paint.

Scenario 2 calls for the tank to be retrofit so it does not sustain any damage should an earthquake occur with water levels up to 18 feet (cycling between 320,000 and 375,000 gallons). In addition to the repairs in scenario 1, the retrofit includes a new foundation, anchorage and reinforcing the rafters. This retrofit will also allow the tank to be operated up to the maximum operating level of 23 feet (cycling between 375,000 and 485,000 gallons) without a catastrophic failure. The Tank roof will be damaged if an earthquake occurs if the water level is between 18 and 23 feet. The roof can be repaired or replaced after the earthquake using federal emergency funds. We estimate the cost of the seismic upgrade to be $500,000 for design and construction.

Scenario 3 is to retrofit the tank so the roof does not sustain any damage with the water level over 18 feet. The analysis indicates the entire roof has to be cut out and removed. It would then be replaced with a new roof structure capable of withstanding the water sloshing forces up to water levels of 24 feet. The cost for this scenario is prohibitively expensive and therefore not recommended.

Water District Proposal

The Water District proposes the following cost sharing agreement with the Fire District to retrofit and upgrade the Page Mill Tank with a split of $300,000 (37.5%) for the Water District and $500,000 (62.5%) for the Fire District

Fire Commissioners: 3/30/2014

Following are some notes and thoughts about the options you have available with regard to “The Page Mill Tank”. These are strictly my own musings and do not necessarily represent those of the sub-committee which met to discuss the issue.

Background on the tank. It is the highest elevation tank in the district, and is thus of strategic significance in that (unlike other tanks that are lower in elevation) it can provide gravity feed to any other tank in town. As such it provides a universal backup capability in case any other tank goes off-line. In practical terms, this tank would primarily be used as backup in its own bailiwick of zone 4 for either short-term backup (e.g. temporary low pressure) or longer term backup (e.g. earthquake-related damage). For cross-zone backup it likely would only be relevant for short-term backup to other zones, and any longer term backup in those other zones could very likely be handled with more localized redundancy/excess capacity. So while this “universal backup” attribute has strategic significance, this factor does not stretch to the extent of providing justification for a larger tank.

The ½ Million Gallon figure is deceiving – in practical terms the tank cannot hold that amount. The nominal 24ft height cannot all be used because space has to be left for sloshing in case of earthquake – filling to the brim of the tank could cause the roof to take a hit from water movement. Such an occurrence would probably not lead to catastrophic failure, but “only” a significant repair situation. But we’re talking probabilities here, it could also turn out worse. So about 5ft leeway is always left at the top.

In fact the tank is almost never at capacity for other reasons – the water level swings regularly from min to max to ensure cycling of the water so it doesn’t become stale. During winter, the height of the min-to-max span is lower than during summer (when more water is used) to ensure sufficient refresh cycling takes place. Thus the water level (i.e. volume of water in the tank) at any given moment in time is going to be somewhere between min and max. If the rise-and-fall followed a symmetric sine wave, we could think of the most statistically likely volume at any time as being related to the RMS of this min/max level.

This is important when we compare the apparent gain we might get by going from a 500,000 gallon capacity to a 900,000 gallon capacity. The apparent “nearly doubling” of water capacity is in fact quite a bit less because in neither case would the tank hold near that amount.

Basically we are faced with making a choice between 3 options:

a) Do nothing – Best current estimate (BCE) is $0
b) Seismic Upgrade – BCE around $800K
c) Replace with new tank going from 500K gallon to 900K gallon - BCE around $4 million

Option (a) to do nothing would be close to irresponsible unless we really don’t have the money. This tank dates from the ‘60’s (or possibly earlier) and is within 2 miles of 2 significant earthquake faults where we are told we can expect a 6.9 or 7.2 Richter event respectively at some point. To put this in

perspective, we are lucky this tank still stands. The Loma Prieta event in 1989 was a 6.9 on one of these faults with epicenter approx 30 miles away. During that event, a 1Million Gal. tank located on La Cresta (not far from, and just up-hill from, Town Hall) failed catastrophically and dumped its contents down the hillside. The type of construction of this tank was different to that of our subject tank, and as such the cause of its failure would not apply to our subject tank. Nevertheless it is probably safe to say the Page Mill tank dodged a bullet on that one, we may not be as lucky when the next one hits. It's bad enough to lose a tank that serves 200-300 households when the big one hits and for which there is no higher backup within the district – it's even worse when that tank is also your "universal backup" for a large other section of town at lower elevation.

So let's take a look at option (b). Currently the tank doesn't even sit on a foundation as one normally understands these things. In fact you can think of the base as being a circular concrete ring with a cross-section of 1ft by 1ft, and the ring is filled with sand, i.e. the ring should be considered more of circular belt designed to contain a 1ft layer of sand rather than a "foundation". It is a flat "pad" on which the tank rests.

The tank is connected to the outside world by two inlet/outlet pipes that enter the side-wall and have a certain amount of "give" should the tank move a little bit. But there is also a pipe entering the floor of the tank to allow the tank to be drained for maintenance purposes – and this connection is unlikely to allow for any tank movement (horizontal or vertical) without rupturing the floor of the tank. Given that during Loma Prieta some horizontal displacements of up to 2 meters at an acceleration of 4G were not uncommon… in such a scenario, having the whole tank slip or hop some number of feet off its pad with attendant rupturing of pipe connections and floor, as well as possible wall rupture – I wouldn't want to bet against it happening within the next 50 years.

We can never (afford to) build a tank guaranteed to withstand any earthquake. But we can apply the 80/20 rule – for 20% of the money, we can have 80% confidence it will survive. Bottom line on option (b) is that seismic upgrade of the tank is the minimum responsible thing to do.

Now consider option (c) – build a new tank – up to current seismic standards and with (nominal) 900,000 Gal. capacity for BCE around $4Million.

Do we need the extra capacity? It would appear that the current capacity is sufficient for both domestic use as well as wildland fire protection. Given that the tank could sustain around four concurrent structure fires (Assume tank is ½ full, 4 times 1250 Gallons/Minute allows 50 minutes sustained) and wildland fires require even less (an engine carrying 800 gallons can refill over 300 times from ½ full tank) – The Short answer is "No".

So the question of the (less than stellar) "cost effectiveness" (i.e. $4M to less-than-double the capacity) is actually moot. Even if it is a heck of a bargain - If you don't need it, you don't need it. Period.

One possible justification might be future growth. Why spend money now on a seismic upgrade if you're going to have to replace the tank anyway with a larger size in the foreseeable future? This tank serves an area that is not likely to see much increase in population or residential structures. The general area is

dominated by Mid-Pen lands and Palo Alto's Foothills Park – I doubt either of them are contemplating putting in a sub-division. We can expect a few more houses to be built or re-developed to be larger over time, but I suspect the number is countable on the fingers of two hands.

So – in summary it seems clear to me that option (b) to do the seismic retrofit at a BCE of $800,000 is the correct way to go. The other two options don't even come close to being justifiable alternatives.

Again – this is my own thinking on the matter, not necessarily that of the sub-committee, but I'm under the impression they would at least concur with this conclusion.

Jitze Couperus