APPENDIX 13A

Overtopping Release Fraction

OVERTOPPING RELEASE FRACTION

In the PAFF assessment physical modelling was undertaken for release scenarios of the PAFF tanks [3]:

Table 13A-1: Summary of Instantaneous Release Experiments (Table 10.48 in [3])

Test	Description
A	Instantaneous tank removal (100% fill level)
B	Unzipping (100% fill level)
C	Unzipping (80% fill level)
D	Panel failure of 1m high by 10m wide (100% fill level)
E	Panel failure of 1m high by whole perimeter (100% fill level)

The following main results were produced for the two cases of relevance here:

Table 13A-2: Summary of Relevant Bund Overtopping Results from PAFF Physical Modelling [3]

Measured Location	% of Initial Liquid for Test	
	A	B
Retained in Primary Bund	75	73
Between Primary and tertiary wall	11	14
Drainage from EVA road	1	1
Overtopping onto public road and beyond	5	9
Overtopping containment towards sea	8	0.5
Overtopping step within SWS building	0	2.5

The tanks at the AFTF are expected to be either 100% full or 50% full based on information from AAHK.

Table 13A-3 shows a comparison of the dimensions of the PAFF tanks and the existing and new extension AFTF tanks:

Table 13A-3: Comparison of PAFF Tank and AFTF Tank Dimensions

Description	PAFF	Existing	New Extension
Bund wall height	4.8m	1.5m	3.5m
Min distance between bund and tank	10m	10m	10m
Distance between primary bund and secondary bund/security fence	8.5m	12m	8.5m
Height of secondary bund	5.2m	Approx. 2m	Approx. 5m
Distance from bund to security fence (or in the case of the PAFF the tertiary bund wall (2.4m))	4m	4m	4m
Height of tanks	25m	20m	20m
Diameter of tanks	43.5m	39m or 27.5m	34m

To adapt the results to the AFTF we make use of the general bund overtopping formula for vertical bunds:

$Q = 0.044 – 0.264\ln(h/H) -0.116\ln(r/H)$ Equation A [20],

where h is the height of the bund wall, H is the height of the tank, and r is the distance of the centre of the tank from the bund. This equation has been used to calculate the overtopping from all the tanks at the airport tank farm but due to the arrangements of the bunds (as was the case with the PAFF assessment) it tends to overestimate as compared with the experimental results for a multi-tank bund.

To scale the initial overtopping from the PAFF experiments to the AFTF we use equation A and the dimensions in the **Table 13A-3**.

Factors which effect bund overtopping are H, h and r. We scale the experimental results with respect to H and h. Scaling does not use r because for the PAFF tanks and the AFTF the minimum spacing of the bund from the tank wall is the same; r is nominally taken as 30m in each case.

100% Full Tanks

Using equation A, keeping h and r constant and varying H between 25m and 20m the overtopping fraction changes from 0.459 to 0.374, which is an 18% decrease in overtopping fraction.

For Test A overtopping with H=25m is 25%, therefore overtopping with H=20m is ((1-0.18)×25%) = 20.5%, which is a 4.5% decrease in overtopping fraction, resulting in a 4.5% increase in liquid retained in the primary bund due to the change in H.

For Test B overtopping with H=25m is 27%, therefore overtopping with H=20m is ((1-0.18)××27%) = 22.1%, which is a 4.9% decrease in overtopping fraction, resulting in a 4.9% increase in liquid retained in the primary bund due to the change in H.

Using equation A, keeping H and r constant and varying h between 4.8m and 1.5m (Existing) and between 4.8m and 3.5m (New Extension), the overtopping fraction increases by a 67% for the existing facilities and 18% for the New Extension facilities.

For Test A overtopping with H=25m is 25%, therefore overtopping with h=1.5m is (1.67x25%)=41.8%, which is a 16.8% increase in overtopping fraction, resulting in a 16.8% decrease in liquid retained in the primary bund due to the decrease in the bund wall for the existing facilities. For the New Extension facility with h=3.5m the overtopping increases to (1.18x25%)=29.5%, which is an increase of 4.5% in overtopping fraction giving a 4.5% decrease in liquid retained in the primary bund due to the decrease in bund wall for the New Extension facilities.

For Test B overtopping with H=25m is 27%, therefore overtopping with h=1.5m is (1.67x27%)=45.1%, which is a 18.1% increase in overtopping fraction, resulting in a 18.1% decrease in liquid retained in the primary bund due to the decrease in the bund wall for the existing facilities. For the New Extension facility with h=3.5m the overtopping increases to (1.18x27%)=31.9%, which is an increase of 4.9% in overtopping giving a 4.9% decrease in liquid retained in the primary bund due to the decrease in bund wall for the New Extension facilities.

The new percentages for tests A and B for both the existing and New Extension facilities at the facility under consideration are given in **Table 13A-4**:

Table 13A-4: Predicted Fractions Retained in Primary Bund for Instantaneous Failure of a Full AFTF Tank

Location	**% of Initial Liquid (Existing)**		**% of Initial Liquid (New Extension)**	
	A	**B**	**A**	**B**
Retained in Primary Bund	(75%+4.5%-16.8%) = 63%	(73%+4.9%-18.1%) = 60%	(75%+4.5%-4.5%) = 75%	(73%+4.9%-4.9%) = 73%

The second effect is the liquid which spreads between the primary and tertiary bund. However at the AFTF there is no tertiary bund, only a secondary one, so from the PAFF assessment we calculate the ratio in heights between the second and third bund walls.

Secondary bund wall = 5.2m in height; Tertiary bund wall =4.4m. Therefore the secondary wall is 5.2/4.4 = 1.2 times higher and it can be assumed that it will retain 1.2 times more of the liquid than the tertiary wall.

For Test A 11% of the fluid spreads between the primary and tertiary walls, this can be split into: (1.2/2.2)x11 = 6% between the primary and secondary walls and (11-6) 5% between the secondary and tertiary walls.

For Test B 14% of the fluid spreads between the primary and tertiary walls, this can be split into: (1.2/2.2)x14 = 7.6% between the primary and secondary walls and (14-7.6) 6.4% between the secondary and tertiary walls.

These new percentages can now be applied to the pool spread between the primary and secondary bund walls at the AFTF (New Extension and existing).

To adapt these percentages account needs to be taken of the different distances between the primary and secondary bund walls.

For the existing facility the separation between the primary and secondary walls is 3.5m greater (41% greater) than at the PAFF facility, however the wall height is 3.2m less (62% less) than at the PAFF facility. By considering the differences in cross-sectional areas (1.41 x 0.38 = 0.54), we make the assumption that less liquid will be retained by the secondary wall at the existing facility than at the PAFF, approximately 46% less, due to the differences in dimensions.

For Test A, the liquid retained by the secondary bund wall is:
((6/(100-75)) x (100-63))% x 0.54 = 5% liquid retained by secondary bund wall

For Test B, the liquid retained by the secondary bund wall is:
((7.6/(100-73)) x (100-60))% x 0.54 = 6% liquid retained by secondary bund wall

For the New Extension facility on comparison to the PAFF the separation between the primary and secondary bund walls are the same (8.5m) and the height of the secondary wall is approximately the same as the PAFF. Therefore the same percentages can be used as those in the PAFF.

For Test A, the liquid retained by the secondary bund wall is:
(6/25) x (100-75) % = 6% liquid retained by secondary bund wall

For Test B, the liquid retained by the secondary bund wall is:
(7.6/27) x (100-73) % = 8% liquid retained by secondary bund wall

Table 13A-5 summarises the results for tanks that are 100% full.

Table 13A-5: Overtopping Estimates for 100% Instantaneous Failure of Full Tanks

Location	**% of Initial Liquid (Existing)**		**% of Initial Liquid (New Extension)**	
	A	**B**	**A**	**B**
Retained in Primary Bund	63%	60%	75%	73%
Retained between primary and secondary bunds	5%	6%	6%	8%
Amount of liquid which overtops the secondary bund wall and spreads in a pool	32%	34%	19%	19%

It may be noted that the fraction of the tank contents predicted to overtop the secondary bund is higher than for the PAFF tanks due to the differing bunding arrangement. Although the situation has been examined in some detail to compare with the PAFF tank physical modelling, the overall risk assessment results are not expected to be very sensitive to the exact overtopping fraction used.

50% Full Tanks

For the case of a tank when it is 50% full, paragraph 10.6.7.7 of the PAFF assessment [3] states "*For fill heights between 35 and 60% the predicted result is a spill contained within the security wall.*" Therefore, for a 50% full PAFF tank all of the liquid was predicted to be retained by the primary, secondary and tertiary bund arrangement.

We assume that at the PAFF, for a tank which is 50% full, 100% of the fluid will be retained by the primary, secondary and tertiary bund arrangement and consider the fraction that would overtop the secondary bund for the Existing and New Extension tank farms.

Looking at the PAFF experimental results, for Test A the proportion of fluid retained by the bunding arrangement is (75 +11)%, as shown in a previous calculation only 5% of the 11% retained between the primary and tertiary bund is retained between the secondary and tertiary bund. Therefore, assuming that 100% is retained by the bunding arrangement then 5/(75+11) = 6% of the total retained fluid is retained between the secondary and tertiary bunds.

For Test B the proportion of fluid retained by the bunding arrangement is (73 +14)%, as shown in a previous calculation only 6.4% of the 14% retained between the primary and tertiary bund is retained between the secondary and tertiary bund. Therefore, assuming that 100% is retained by the bunding arrangement then 6.4/(73+14) = 7% of that fluid is retained between the secondary and tertiary bunds.

Applying this logic to the existing facility for Test A, 32% of the fluid overtops the secondary bund, comparing this to the PAFF results, 14% overtops the tertiary bund, or (14+5) 19% overtops the secondary bund. This means that 1.7 times as much fluid overtops the secondary bund wall at the existing facility as compared with the PAFF facility.

Therefore, if 6% of the 100% of fluid retained in the bunding arrangement at the PAFF is held between the secondary and tertiary bunds. For test A at the existing facility with the tank 50% full, (1.7 x 6) = 10% overtops the secondary bund wall, with the rest of the fluid retained by the bunding arrangement.

For Test B, 34% of the fluid overtops the secondary bund, comparing this to the PAFF results, 13% overtops the tertiary bund, or (13+6.4) 19.4% overtops the secondary bund. This means that 1.8 times as much fluid overtops the secondary bund wall at the existing facility as compared with the PAFF facility.

7% of the 100% of fluid retained in the bunding arrangement at the PAFF is held between the secondary and tertiary bunds. For test B at the existing facility with the tank 50% full, (1.8 x 7) 13% overtops the secondary bund wall, with the rest of the fluid retained by the bunding arrangement.

Applying this logic to the New Extension facility for Test A, 19% of the fluid overtops the secondary bund, comparing this to the PAFF results, 14% overtops the tertiary bund, or (14+5) 19% overtops the secondary bund. This means that 1 times as much fluid overtops the secondary bund wall at the existing facility as compared with the PAFF facility.

Therefore, if 6% of the 100% of fluid retained in the bunding arrangement at the PAFF is held between the secondary and tertiary bunds. For test A at the existing facility with the tank 50% full, (1 x 6) 6% overtops the secondary bund wall, with the rest of the fluid retained by the bunding arrangement.

For Test B, 19% of the fluid overtops the secondary bund, comparing this to the PAFF results, 13% overtops the tertiary bund, or (13+6.4) 19.4% overtops the secondary bund. This means that 0.98 times as much fluid overtops the secondary bund wall at the existing facility as compared with the PAFF facility.

Therefore, if 7% of the 100% of fluid retained in the bunding arrangement at the PAFF is held between the secondary and tertiary bunds. For test B at the existing facility with the tank 50% full, (0.98 x 7) 7% overtops the secondary bund wall, with the rest of the fluid retained by the bunding arrangement.

Table 13A-6 summarises the results for tanks that are 50% full.

Table 13A-6: Overtopping Estimates for 100% Instantaneous Failure of 50% Full Tanks

Location	% of Initial Liquid (Existing)		% of Initial Liquid (New Extension)	
	A	B	A	B
Retained in Primary and Secondary Bunds	90%	87%	94%	93%
Amount of liquid which overtops the secondary bund wall and spreads in a pool	10%	13%	6%	7%