14 VIBRATION

1. This section describes the potential vibration levels that are predicted to arise during the construction (e.g. due to piling) and operational (e.g. due to container handling and train movements) phases. Vibration levels have been predicted on the basis of measurements that have been made of passing trains and tests that have been undertaken that simulate container handling. Potential impact on sensitive structures, comprising flood defences and Landguard Fort and museum, have been assessed.

14.1 EXISTING ENVIRONMENT

14.1.1 Vibration from operational port

1. The only potential source of vibration associated with the operating terminal is that associated with the movement of containers. However from previous investigations undertaken, no impact of this type is anticipated for the proposed development. Container handling will not take place any nearer to potentially sensitive properties than at present.

14.1.2 Railway induced vibration

1. Figure 13.1.5 gives the results of vibration measurements of train events taken at St Mary's Close, Trimley St Martin. This shows the peak particle velocity (PPV) in mm/s and these measurements were made to assess the potential for structural damage due to vibration from passing trains. Each of the events shown in this figure can be time correlated with a particular train event. The highest vibration level of 1.9 mm/s PPV was associated with a non-container freight train. The range and average values for the PPVs of all train events are shown in Table 14.1.1.

Table 14.1.1 Range and average vibration levels for different categories of train as measured at St Mary's Close, Trimley St Martin

Train category	Range of PPV (mm/s)	Average PPV (mm/s)
2 carriage passenger train	0.6 - 0.9	0.7
1 carriage passenger train	0.3 - 0.5	0.4
Container freight train	0.7 - 1.2	0.9
Non-container freight train	0.4 -1.9	1.2
Engine only	0.8 - 1.3	1.1

2. Measurements of vibration dose values for passing trains were taken at another site adjacent to the same railway line, at the Northgates Sport Centre in Ipswich. The measurements were taken at a distance of 20m from the centre of the track, which is closer to the track than the properties at St Mary's Close, Trimley St Mary. The results of these measurements are given in Table 44 (Appendix 6), and the calculations of VDV values for day and night periods are given in Table 45 (Appendix 6).

14.2 POTENTIAL IMPACTS DURING THE CONSTRUCTION PHASE

14.2.1 Potential impact of vibration on sensitive structures

1. The most significant source of vibration during the construction works will be from the tubular steel piling for the quayside wall. BS5228 (1992) provides guidance for the prediction of an upper estimate of vibration from impact piling operations which is based on the energy per blow or cycle (determined by the type of piler and ram weight), the distance of the receptor from piling and generalised soil conditions. There are several other prediction techniques in existence, and in general, these provide lower estimates of vibration than given in BS5228 (1992).

2. The following calculated levels are based on a hammer delivering a maximum energy per blow of 200 kJ. It is considered unlikely that this full force will be required at all stages of the pile driving, and therefore a prediction has also been undertaken for the hammer delivering half of this energy. The results are given in Tables 13.2.1 and 14.2.2. Table 14.2.1 refers to vibration levels outside the building, and the results do not take any account of amplification of vibration that normally occurs from the outside of building to a floor structure inside the building. This is often taken as a factor of 2 as shown in Table 14.2.2.

Table 14.2.1 Predicted pile driving induced vibration levels (combi-wall construction, based on BS 5228 Part 4) at various locations

Piling	Energy (kJ)	Range of combi-wall piling induced vibration levels (ppv mm/s)							
		F1	F3	F4	F6	F7	H4	LM	SG
Phase 1	200	0.3 - 0.5	0.2 - 0.4	0.2 - 0.2	0.2 - 0.2	0.2 - 0.2	0.2 - 0.2	0.2 - 0.5	0.1 - 0.1
Phase 2	200	0.3 - 0.5	0.4 - 0.4	0.2 - 0.2	0.2 - 0.2	0.1 - 0.2	0.2 - 0.2	0.5 - 3.0	0.1 - 0.1
Phase 1	100	0.2 - 0.3	0.2 - 0.3	0.2 - 0.2	0.1 - 0.2	0.1 - 0.1	0.1 - 0.1	0.2 - 0.4	0.1 - 0.1
Phase 2	100	0.2 - 0.3	0.3 - 0.3	0.2 - 0.2	0.1 - 0.2	0.1 - 0.1	0.1 - 0.1	0.4 - 2.2	0.1 - 0.1

Table 14.2.2 Predicted pile driving induced vibration levels in internal floors (combi-wall construction)

Piling	Energy (kJ)	Range of combi-wall piling induced vibration levels (ppv mm/s)							
		F1	F3		F6	F7	H4	LM	SG
Phase 1	200	0.7 - 1.0	0.5 - 0.7	0.4 - 0.5	0.4 - 0.5	0.3 - 0.4	0.3 - 0.4	0.5 - 1.0	0.2 - 0.2
Phase 2	200	0.7 - 1.0	0.7 - 0.8	0.4 - 0.5	0.4 - 0.4	0.3 - 0.3	0.3 - 0.4	1.0 - 6.1	0.2 - 0.2
Phase 1	100	0.5 - 0.7	0.4 - 0.5	0.3 - 0.4	0.3 - 0.3	0.2 - 0.3	0.2 - 0.2	0.3 - 0.7	0.1 - 0.1
Phase 2	100	0.5 - 0.7	0.5 - 0.6	0.3 - 0.4	0.2 - 0.3	0.2 - 0.2	0.2 - 0.2	0.7 - 4.3	0.1 - 0.1

3. Piling for the new quay wall would, at its southern end, be relatively close to Landguard Fort, Landguard Museum and existing flood banks. The results of calculation of maximum vibration levels from the quay wall piling operations are also presented for these areas (Table 14.2.3).

Table 14.2.3 Piling induced combi-wall piling vibration levels for potentially vibration-sensitive structures

Piling	Energy (kJ)	Maximum combi-wall piling induced vibration levels (ppv mm/s)			
		Landguard Museum	Landguard Fort, Southern Battery	N flood bank by viewing area	S flood bank, Landguard Fort
Phase 2	200	3.0	4.8	5.6	13.4
Phase 2	100	2.2	3.4	4.0	9.5

4. Based on the prediction technique employed, vibration levels from piling operations are likely to be satisfactory at a distance beyond 1km from the piling rig used for the combi-wall piling, when operating at maximum energy. Particular sensitive people may perceive vibration at a greater distance than this. Between 600m and 1km some limited adverse impact may be perceived but adverse comments would only be expected at distances less than 600m from the rig.

5. At distances less than 300m from the rig, adverse comments would be probable. In reality the piling rig would most likely not normally be used at maximum capacity as it is normal practice to have reserve capacity in case a difficulty is encountered during the piling operation. At half capacity, adverse comments would be probable at a distance of 200m or less from the rig. This excludes all residential properties, but includes Landguard Fort and Museum during the latter stages of Phase 2 piling. However, these structures are substantial, and it is likely that there would not be the same amplification effects of vibration from outside to inside as for normal residential properties. This may, therefore, reduce any significant impact until the piling rig is some 100m from the museum and fort.

6. There is no concern over any structural damage to the Fort or Museum from piling induced vibration as predicted vibration levels are significantly below those that could give rise to cosmetic damage in normal residential buildings. BS7385 (1993), which is followed in this ES, also states:

> *"A building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive".*

7. The highest vibration level at any potentially sensitive location is likely to be felt at the flood bank to the south of Landguard Fort. With the rig operating at full capacity a PPV of 13 mm/s is predicted here. This is above the level for cosmetic damage to residential buildings from intermittent vibration (10 mm/s) although below the threshold for damage to industrial buildings (20 - 30 mm/s for intermittent vibration). Whilst it is considered unlikely that any significant damage to the bank would be caused, this would probably depend on the state of the bank. It is, therefore, recommended that vibration monitoring is undertaken at the Fort, Museum and flood banks, during the latter half of Phase 2 quay wall construction.

8. The potential impact of vibration from quay wall piling is considered to be of **negligible significance** generally, but of **moderate adverse significance** to Landguard Museum, and the flood banks during the latter stages of the piling for the quay wall for Phase 2 of the proposed development.

Mitigation and residual impact

9. During piling operations, monitoring of vibration levels should take place on nearby potentially sensitive structures during the latter stages of the piling for the quay wall for Phase 2.

10. Where vibration levels look likely to exceed threshold levels for structural damage, then the maximum energy per blow should be reduced although this could have the effect of extending piling operations.

11. With vibration monitoring safeguarding the integrity of structures, the residual impact would be of **negligible to minor adverse significance**.

14.3 POTENTIAL IMPACTS DURING THE OPERATIONAL PHASE

14.3.1 Potential impact of vibration on sensitive structures due to container handling

1. There is no perceived impact from operational vibration (e.g. container handling) with respect to any residential properties. Other structures that are potentially sensitive to vibration from container handling are flood defences and Landguard Fort. However, no impact of this type currently occurs and none is foreseen with the reconfigured terminal as container handling would take place at no closer distance than at present, and in any case vibration levels would be very low. There would, therefore, be be **no impact** to residential properties or other structures.

Mitigation and residual impact

2. No mitigation measures are required and there would be **no residual impact.**

14.3.2 Potential impact of vibration arising from port operations

1. In addition to vibration arising from the handling of containers (assessed in Section 14.3.1 above), other sources of vibration during the operational phase comprise road and rail traffic.

2. The vibration arising from existing train movements (discussed in Section 14.1) indicates that there is no evidence of any significant levels of vibration due to existing train movements. Therefore, vibration from future train movements would not be significant given that there is no reason to suggest that vibration levels would be greater for an individual train movement in the future. However, overall vibration dose values will increase slightly. Overall, an impact of **negligible significance** would be expected with respect to human annoyance or potential structural damage. Similarly, the impact from road traffic vibration is considered to be of **negligible significance**.

Mitigation and residual impact

3. The maintenance of the railway track and highways in a good condition will help to ensure that vibration levels remain of **negligible significance**. However, it should be noted that such maintenance is beyond the control of HPUK with the exception of sections of the road and rail network that are within the limits of HPUK jurisdiction (i.e. within the boundaries of the Port of Felixstowe).