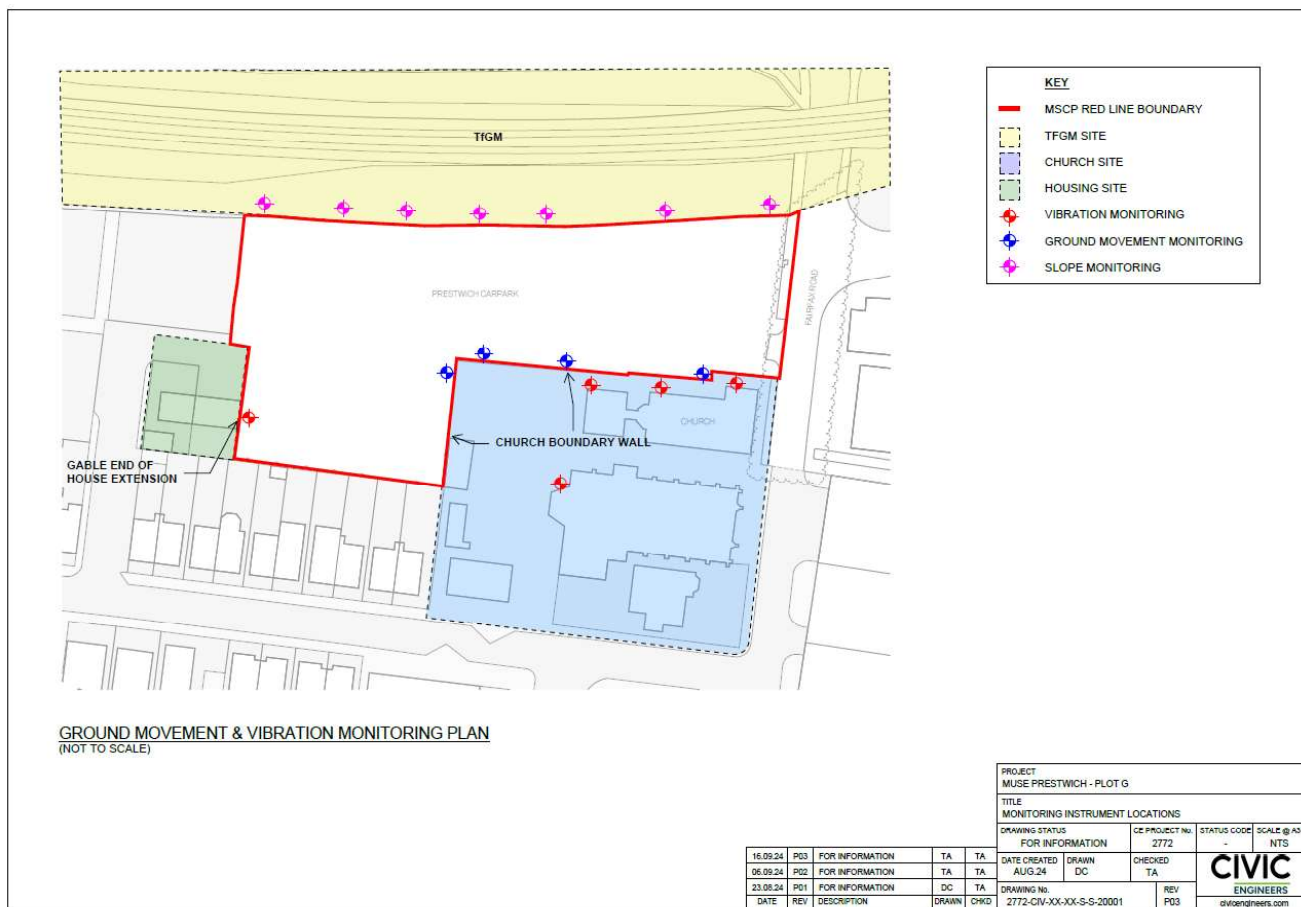


## MONITORING LAYOUT / PROPOSAL



## Technical Proposal for Instrumentation, Ground, Slope, and Vibration Monitoring System

**Project Title:** Ground, Structural, and Vibration Monitoring

**Prepared for:** MUSE Prestwich – Plot G

### 1. Introduction

This proposal outlines the plan for ground, slope, structural movement, and vibration monitoring during earthworks and piling activities at the MUSE Prestwich – Plot G development site. The updated system will use tri-axial tilt sensors for slope and ground movement monitoring, a 3D manual monitoring system using reflective targets and total stations instead of levelling studs and BRE sockets, and continuous vibration monitoring. The monitoring schedule has been revised to conduct reflective target readings once a week, while tilt and vibration sensors will provide continuous real-time data.

### Objectives

- To monitor slope stability, ground movements, and vibration impacts near adjacent structures and infrastructure.
- To ensure that displacements and vibrations remain within acceptable limits to prevent damage to nearby buildings and infrastructure.
- To provide real-time alerts if any movements or vibrations exceed established trigger levels.
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## 2. Monitoring Scope

The monitoring scope will include:

- **Slope Monitoring:** Tri-axial tilt sensors on pegs to monitor slope stability along the northern boundary near the TfGM boundary.
- **Ground Movement Monitoring:** Tri-axial tilt sensors on beams to monitor ground movement along the southern boundary near the church.
- **Vibration Monitoring:** Triaxial vibration sensors will be installed at key locations to monitor the impact of construction-induced vibrations.
- **3D Manual Monitoring:** Reflective targets and total stations will be used to measure positional changes in nearby structures. Backup reflective targets will be installed on pegs where visibility allows.
- Tilt sensors and vibration sensors will provide continuous monitoring, while reflective target readings will be conducted once a week.

## 3. Instrumentation

### 3.1 Tri-Axial Tilt Sensors for Slope and Ground Movement Monitoring

- **Slope Monitoring:** Tri-axial tilt sensors will be installed on pegs along the northern boundary to monitor lateral and vertical movements in the slope.
- **Ground Movement Monitoring:** Tri-axial tilt sensors will be installed on beams along the southern boundary adjacent to the church to detect ground movements during excavation and piling activities.

#### Installation

- Sensors will be installed at key locations to detect potential movements in both the slope and ground. Placement will be adjusted in consultation with the instrumentation manager and project engineer, considering site-specific conditions.

#### Specifications

- **Accuracy:**  $\pm 0.1^\circ$  for tilt measurements.
- **Range:**  $\pm 10^\circ$  tilt range.
- **Resolution:**  $0.01^\circ$  to ensure precise and accurate measurements.

### 3.2 3D Manual Monitoring Using Reflective Targets and Total Stations

Reflective targets will be installed on nearby structures, as well as on the pegs used for slope monitoring where visibility allows. These targets will provide a manual method of verifying positional changes and backing up data from the tilt sensors. Measurements will be captured using total stations.

#### Installation of Reflective Targets

- Reflective targets will be placed on facades, walls, and other critical points of interest to measure both vertical and horizontal displacements.
- Targets will be installed at various heights on the structures to ensure full coverage of potential movement patterns.
- Backup reflective targets will be installed on the pegs used for slope monitoring to provide additional data points, especially where visual monitoring is feasible.



### Total Station Monitoring

- Weekly readings of the reflective targets will be taken manually using a total station to capture the exact position of each target in 3D space (x, y, z coordinates).
- This data will serve as a verification for movements detected by the tilt sensors, offering an additional layer of redundancy.

### 3.3 Vibration Monitoring

Vibration monitoring is essential to ensure that construction-induced vibrations do not exceed acceptable limits, thereby preventing damage to nearby structures. Triaxial vibration sensors will be used to capture data on vibrations caused by piling, excavation, and other heavy equipment.

#### Installation of Vibration Sensors

- Triaxial vibration sensors will be installed at critical locations along the site boundary and near sensitive structures, including the church and nearby housing development.
- Sensors will measure peak particle velocity (PPV) in all three axes (x, y, z) to detect any potentially harmful vibration levels.

#### Vibration Monitoring Parameters

- **Frequency Range:** 4 Hz to 250 Hz, in line with BS7385-2:1993 standards for structural vibration.
- **PPV Trigger Levels:**
  - **Green Trigger:** Early warning, no action required.
  - **Amber Trigger:** Review and adjust construction activities.
  - **Red Trigger:** Immediate cessation of work, followed by investigation and potential structural inspection.

### 3.4 Frequency of Monitoring

- **Continuous Monitoring:** Both the tri-axial tilt sensors and the vibration sensors will provide continuous monitoring. These sensors will log data in real-time, with continuous uploads to the secure web portal for immediate analysis and reporting. Alerts will be generated automatically if any readings exceed the predefined trigger levels.
- **Weekly Manual Monitoring:** Reflective targets installed on structures and backup targets on the slope monitoring pegs will be read manually once a week using total stations. This data will be compared to the baseline readings and used to cross-verify movements detected by the tilt sensors.

Backup reflective targets will provide additional data where visibility allows, offering redundancy in case of any issues with the tilt sensors or in situations where visual confirmation is required. This dual approach ensures accuracy and reliability in the monitoring system.

## 4. Reporting and Data Capture

### 4.1 Data Collection

- **Tilt Sensor Data:** Data from the tri-axial tilt sensors will be continuously collected and uploaded to a secure web portal within 24 hours for analysis.
- **Vibration Data:** Triaxial vibration sensors will provide continuous real-time data on PPV levels. Alerts will be triggered immediately if vibrations exceed the green, amber, or red trigger thresholds.



- **Total Station Data:** Reflective target measurements will be manually taken once a week. The 3D positional data will be compared against baseline values to track any movements.

#### 4.2 Data Presentation

- All monitoring data will be accessible via a secure web portal. The portal will provide graphical representations of the data, showing time histories for tilt and vibration readings, along with comparisons to trigger limits (green, amber, red).
- The reflective target readings will be incorporated into weekly reports, with any anomalies or movements beyond trigger levels highlighted for review.
- The portal will allow stakeholders to download data in Excel format for detailed analysis and record-keeping.

#### 4.3 Reporting

- **Weekly Reports:** A weekly report will be generated, summarizing the data collected from tilt sensors, vibration sensors, and total station readings. This report will include:
  - Executive summary of key findings.
  - Comparison to baseline readings and analysis of any significant movements or vibrations.
  - Recommendations for any necessary actions based on data trends.
- **Contingency Reporting:** If any amber or red trigger levels are breached, immediate reports will be issued detailing the actions to be taken and any changes to the construction methodology or monitoring schedule.

#### 5. Contingency and Action Plan

In the event of a trigger level breach, the following steps will be implemented:

- **Green Trigger:** No immediate action, but continuous monitoring will continue.
- **Amber Trigger:** Review of construction activities and possible adjustment to methods or monitoring frequency. Visual inspections of nearby structures may be required.
- **Red Trigger:** Immediate cessation of work, with an in-depth investigation into the cause of the movement or vibration. Visual inspections of all affected structures will be conducted, and contingency measures such as temporary supports or redesigns may be implemented.

#### 6. Conclusion

This revised proposal integrates continuous monitoring of slope and ground movements using tri-axial tilt sensors, continuous vibration monitoring, and weekly manual monitoring with reflective targets. The dual-layered approach, including backup reflective targets on pegs, ensures that the monitoring system is both robust and reliable, safeguarding nearby structures from potential damage due to construction activities. The secure web portal will provide real-time data access and alert stakeholders if any trigger levels are breached, allowing for timely and effective interventions.

By adopting this comprehensive monitoring system, we ensure that the MUSE Prestwich – Plot G development progresses safely, with minimal risk to adjacent structures and infrastructure.



## METHODOLOGY, NOTES & DELIVERABLES

### MON01-01 HSQE Documentation & Project Preparation

Provision of an office-based monitoring project manager to compile a risk assessment and method statement to conform to CDM regulations.

RAMS will detail the methodology of installation, surveying and reporting, and all risks associated with each task. Item also includes general project consultation from the office.

Also includes instrumentation procurement and project planning.

Provision of experienced project engineer to lead procurement and preparation of equipment. Includes testing and preparing the kit in our facilities prior to deployment.

Also includes ensuring all instrumentation are calibrated as per standards and all paperwork evidence is up to date.

Preparation of dummy web portal for approval by the engineer.

### MON01-02 Installation of Monitoring Network

Provision of a 2-person crew to install the following:

- standard number of reference targets for control.
- up to 15 monitoring reflectors for manual monitoring.
- up to 20 precise levelling points for manual monitoring.
- 4no. tri-axial tilt beams installed on the church boundary wall.
- 7no. tri-axial tilt sensors installed on pegs for slope monitoring.
- 7no. vibration monitoring sensors.

Reflectors will be standard retro-reflective adhesive targets or resin-cast monitoring plaques.

Manual monitoring targets will be non-intrusively fixed to the asset to be monitored.

Access to neighbouring buildings to be arranged by the client.

Installation assumed through windows and/or using long poles.

Precise levelling points can be domed headed survey marker or Hilti type nails, and BRE sockets.

Precise levelling points will be intrusively fixed into the asset to be monitored.

No allowance for powered access or scaffolding has been made for.

Allowance for 2 number of shifts @ £815.00 per shift

### MON01-05 Manual Baseline Monitoring Readings

Provision of monitoring surveyor and high-order precise digital level to carry out baseline readings to installed monitoring studs.

Readings will be adjusted and input into the baseline and installation report to be issued once baseline readings are completed.

Allowance for three readings (visits) - ideally over a duration of 3 weeks @ £425.00 per visit



#### **MON01-06 Baseline and Installation Report**

Compile baseline and installation report showing the stability and repeatability of the baseline readings in tabular and graphical format.

#### **MON02-01 Manual Monitoring and Reporting - 3D monitoring option**

Provision of monitoring surveyor and high-order total station to carry out monitoring readings to installed monitoring targets.

Readings will be adjusted and input into the manual monitoring report.

Summarised reports included (tabular report - no graphs/analysis/conclusions).

Allowance for 24 weekly visits over a duration of 24 weeks (remediation works, piling and groundworks) @ £425.00 per visit

#### **MON02-06 Hire of Vibration Monitoring Station**

5 No. Vibration Monitors (BS 5228:2009, BS 7385:1993, BS ISO 4866:2010) @ £50.00 per unit per week

Includes website enabled data access.

Includes reports upon request from the client (maximum of one report per week).

Includes call-off maintenance visits (for technical matters ONLY - relocation or interventions due to non-technical matters to be priced separately).

Weekly hire rate per week (total): @ £250.00

Assumed hire duration: 27 weeks (3 weeks baseline plus 24 weeks monitoring - during remediation, piling and groundworks)

Vibration Monitor: The vibration monitor we deploy offers an extremely high precision and exceptionally stable three axis vibration sensor which reports its measurements through a cellular network to a central database where it can be analysed in tabular and graphical format. Trigger levels are configurable within entire measurement range of 0-250mm/s or 1Hz to 500Hz. Pre-trigger configurable up to 10 seconds. The vibration sensors installed will be able to record Peak Particle Velocity (P.P.V.).

Our standard mode of measurement is P.P.V. (mm). Other measurements are available on request. Please enquire with us at time of order.

#### **MON02-10 Hire of Structural Health Monitoring Sensors**

Hire of precise wireless geotechnical sensors consisting of the following:

4 No. Wireless Tri-axial Tilt Beams for direct mounting to the structure @ £15.00 per unit per week.

7 No. Wireless Tri-axial Tilt sensors on pegs for direct mounting on the slope @ £15.00 per unit per week.

1 No. 4G gateway @ £135.00 per unit per week including solar panel

Weekly hire rate: £300.00

Hire duration: 16 weeks (3 weeks baseline plus 24 weeks monitoring - during remediation works, piling and groundworks)

Weekly hire of monitoring system which will include the following:

- All the above instrumentation.
- Access to the online viewer and alarming system.
- Set up of automated monitoring database.
- Weekly summary report.
- Maintenance of network (one visit every 3 months).

Measurement output will be in mm/m for tilt sensors. Cant and twist calculations for track mounted tilt sensors. Output for crack gauges will be in mm. Output for strain gauges will be in micro-strain.

#### **MON03-01 Decommissioning of Monitoring Network**

Provision of a 2-person crew to remove the following:

- 4no. tri-axial tilt beams installed on the church boundary wall.
- 7no. tri-axial tilt sensors installed on pegs for slope monitoring.
- 7no. vibration monitoring sensors.

No allowance for powered access or scaffolding has been made for.

Allowance for 1 number of shifts @ £815.00 per shift

#### **MON03-04 Final Report**

Compile final report showing the final conclusions and summary of the monitoring.  
De-installation aspect of the report will show final condition of the installation areas.

#### **MON04-01 Conditions to Costs**

- C01. Mobilisation period 2 weeks
- C02. Stand down rates:
  - 100% if less than 24h notice
  - 80% if less than 48h notice
  - 50% if less than 96h notice
- C03. Safe continuous uninterrupted access per shift provided by client / 3rd party.
- C04. Access type may affect time and cost.
- C05. Nearby parking & access to power required
- C06. We cannot commence works without order or instruction receipt - Standard lead-in time is 2 weeks from instruction.
- C07. Our costs assume all works awarded to Murphy Geospatial.
- C08. If the monitoring scope changes, please request an amended estimate.
- C09. Any additional monitoring equipment or installation required to be charged.
- C10. Our costs include provision of our standard method statements and risk assessments and supporting the client on producing
- C11. Our costs exclude provision for access.
- C12. Welfare facilities to be provided by client on-site.
- C13. Client to accept liability for damage and access costs for maintenance / repair.
- C14. We assume on-site inductions of no longer than 1 hour, any addition chargeable at rates quoted.
- C15. Maximum 8-hour day-time shift / Minimum 5 working hours during night shifts.
- C16. Weekend, bank holiday and evening work to be charged at additional rate (@150%).
- C17. Instrumentation calibration certificates can be made available, if required.
- C18. We have assumed all systems installed sequentially, all as part of the same batch of work.
- C19. Daytime: Mon to Fri - 8am to 5:30pm / Night time: Assume mostly engineering hours site works.
- C20. Interruptions to site work through no fault of our own and associated delays will be chargeable at our standard rates.
- C21. Off-hire of equipment only when de-installed, risk of no access and therefore continuation of hire with client.
- C22. Purchase of equipment is transfer of title of same to billing client. Costs for repair, damage, calibration responsibility
- C23. Access to web-portals for the duration of the project only if sale of equipment is included. Further access to sensor data



- C24. SIM cards, data hosting and licensing for the duration of the project only if sale of equipment is included. All licensing
- C25. Estimate for hire of equipment based on durations provided by customer at time of estimate - shorter duration or termination.
- C26. For Environmental Monitoring projects, if the project exceeds/extends beyond 12 weeks additional charges will be incurred for maintenance works, etc.
- C27. For works on Public areas, an assessment of the risk of theft of the instrumentation will be made, and if additional staff to ensure the equipment security is required, additional charges will apply.

#### **MON04-02 Price Variations on contract period reductions.**

Our offer is based on your supplied expectation of xxx weeks of monitoring duration. Economies of time have been included within our calculations to ensure we can provide the lowest cost of provision of service for the stated monitoring duration. In the event that this period is reduced at any point after instruction we shall be unable to yield cost efficiency over a shorter period and shall therefore apply retrospective price increases as follows:

Reduction in final hire period (weeks) from period as stated in quotation.

Price increase premium retrospectively charged on weekly rate

- 0 - 9 @ 40%
- 10 - 19 @ 35%
- 20 - 29 @ 30%
- 30 - 39 @ 25%
- 40+ @ 20%

For example 5 x sensors quoted for a 100 week duration at £150 per week on which an instruction/order was placed and actual monitoring duration varied by instruction finishes at 28 weeks will result in:

- Initial quotation £75,000 (5no. x 100weeks x £150/wk)
- Final price due to shortened hire period £27,300 (5no. x 28weeks x £150/wk\*130%)

These will be calculated and applied for in our final valuation for the works.

#### **MON04-03 Price Fluctuations.**

##### **1. Price Fluctuations**

1.1. Prices shall be adjusted using an 'Inflation Factor' applied each month at the time of invoicing applicable to the previous months works delivered

1.1.1. 'Contract Base Price per Unit' shall be the agreed Tender price within the agreed Works Contract

1.1.2. A 'Base Month Index' for pricing shall be obtained from the UK Gov ONS published Index for 'Producer Price Inflation' found at

<https://www.ons.gov.uk/economy/inflationandpriceindices/datasets/mm22producerpriceindices>  
downloadable excel sheet worksheet reference 'T1' index code 'GHIP 7390333333' in effect at the month of contract execution

1.1.3. The Inflation Factor shall be the published Price Index for the month before the works were carried out divided by the Base Month Index

1.1.4. The Inflation Factor will be multiplied by the Contract Base Prices to calculate invoice values

#### **MON04-04 Hire Agreement**

Between MGS and the hirer:

This agreement shall apply for the hire of equipment owned by MURPHY GEOSPATIAL (UK) LIMITED (MGS) to any company, firm or individual (the Hirer).



1. These conditions are subject to UK law and any variation may only be agreed upon in writing.
2. The Hirer shall pay MGS during the course of the hire term rental at the rate set out overleaf. Rental is payable for the whole of the term, notwithstanding that the equipment may be returned before the period has expired. Punctual payment shall be a condition of the hiring. If at any time the hirer shall be 14 days or more in arrears MGS shall be at liberty to immediately terminate this hiring and recover the possession of the equipment.
3. In accepting delivery of the equipment, the hirer thereby agrees that the equipment has been inspected, is of satisfactory quality, free from defect and is suitable for the purpose of the hirer.
4. MGS makes no representation or warranty that the equipment is suitable for the hirer's purpose whether made known to MGS or not.
5. Any literature to the Hirer shall not constitute a representation to the Hirer and exclude from these standard conditions of hire.
6. The Hirer shall insure the equipment against loss or damage to the full replacement value thereof whilst in the Hirer's possession or control.
7. The Hirer shall keep the equipment in good and serviceable repair and condition, with fair wear and tear excepted. Any damage caused to the equipment whilst in the Hirer's possession or control shall be deemed the responsibility of the Hirer.
8. If the equipment is not returned within seven days of the completion of the hire term, MGS shall be entitled to deem the equipment lost and to purchase the replacement and the cost shall be charged to the Hirer. If the equipment is returned in a condition which, in the opinion of MGS, is not good and serviceable, MGS may, at its sole discretion repair or replace the equipment and the cost shall be charged to the Hirer at the full list price.
9. The hire term shall not be completed until the Hirer shall return the equipment to MGS in good and serviceable condition, fair wear and tear excepted and hire charges will continue to accrue until in accordance with clause 8 hereof MGS has purchased a replacement of the equipment as the case may be.
10. The equipment shall remain personal property and continue in the ownership of MGS notwithstanding that it may have been affixed to any land or property. If so affixed MGS shall be entitled to enter the property on which the equipment is located without leave and to sever the equipment therefrom and remove it and Hirer shall be responsible for any damage thereby caused.

#### **Insurance:**

For your complete protection, all our work is covered by employer's liability of £10 million, public liability of £10 million and professional indemnity of £10 million. Should you need additional information or confirmation of our policies, please contact our broker.

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