Prepared for
NSW Land and Housing Corporation Department of Planning Industry and Environment (DPIE)
ABN: 24960729253

AECOM

Preliminary Geotechnical Assessment

Riverwood Estate State Significant Precinct

15-Mar-2022
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Prepared by

AECOM Australia Pty Ltd
Level 21, 420 George Street, Sydney NSW 2000, PO Box Q410, QVB Post Office NSW 1230, Australia
T +61 2 8008 1700 www.aecom.com
ABN 20 093 846 925

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Quality Information

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Executive Summary

AECOM Australia Pty Ltd (AECOM) has been engaged by NSW Land and Housing Corporation (LAHC) to undertake a Preliminary Geotechnical Assessment for the Riverwood, Estate State Significant Precinct (The Study Area).

Published information and supplied geotechnical reports have been used to assess likely subsurface conditions for the Preliminary Geotechnical Assessment of a Study Area covering about 30 hectares. The objectives were to assess the risk of significant geotechnical constraints to the proposed redevelopment and to make recommendations for additional geotechnical investigations required to inform the proposed redevelopment of the Study Area.

The expected ground conditions across most of the Study Area comprise a fill layer of variable thickness, overlying residual clay soils, overlying shale bedrock. An exception may be the western Salt Pan Creek side of the Study Area, where alluvial deposits may be encountered, between a fill layer (if present) and then residual soils and/or bedrock.

As the Study Area is relatively low lying and borders Salt Pan Creek a standing regional groundwater table is likely to be encountered within the bedrock profile. In addition, localised perched groundwater is likely to be encountered within fill and at the interface between residual soils and bedrock.

Geotechnical conditions that may affect development include:

- Variable depth and composition of fill
- Potential for soft or compressible alluvium. However, this will be limited to the western boundary of the Study Area, if present
- Moderate and highly reactive residual soil, susceptible to shrink swell volume change with variation in moisture content
- Locally highly saline or sodic soils
- Highly erodible or dispersive soils
- Low subgrade California Bearing ratio (CBR) test results that may require subgrade replacement or improvement
- Groundwater levels impacting on basement excavations
- Poor quality bedrock limiting design parameters for footings

In general, the anticipated ground conditions do not pose significant risks to the feasibility of the proposed development. Geotechnical aspects relevant to the site should be manageable by completing further geotechnical investigations, design and good construction practices at the appropriate stages.

Geotechnical investigations will be required within the Study Area. In particular, assessing whether any landfill and/or alluvium extends on to the Study Area should be an objective of further studies. About 6 to 10 boreholes distributed across the Study Area should provide sufficient information for concept and preliminary design.

For detailed design of medium and high-density residential buildings, further investigations will be required, with cored boreholes taken to below basement levels at each specific site. Pavement investigations will be required for new road layouts or reconstruction of existing roads.

1.0 Introduction

NSW Land and Housing Corporation (LAHC) has engaged AECOM Australia Pty Ltd (AECOM) to prepare a Preliminary Geotechnical Assessment to support the planning proposal for the Riverwood Estate State Significant Precinct (SSP). This report has been prepared to address the Study Requirements for the Riverwood Estate SSP as issued by the Department of Planning, Industry and Environment (DPIE) dated December 2020.

AECOM and a consultant team have worked with LAHC to prepare a master plan for the redevelopment of the site that will renew the existing dwellings, provide for additional private dwellings, new streets and parks and community uses. The proposed master plan consists of approximately 3,900 social and private dwellings, buildings ranging between three and 12 storeys and local open spaces – Roosevelt Park and Play Street and neighbourhood parks.

This report has been prepared to address the relevant Study Requirements for the Riverwood Estate SSP as issued by the Department of Planning, Industry and Environment (DPIE) dated December 2020.

Prepare a Geotechnical and Contamination report that:

- *Provides an assessment of local soil, outlining its suitability for the proposed uses with respect to erosion, salinity and acid sulphate soils.*
- *Provide an assessment of the proposal land uses in accordance with Section 9.1 Direction 2.6 Remediation of Contaminated Land.*
- *Conduct investigations to assess whether the development or future land use are*
- *impacted by contamination. If contamination is identified, identify the appropriate contamination remediation, mitigation and management measures that are required to safeguard the environment and people during construction and use of the proposed development. Investigations must:*
    - *be prepared in accordance with relevant guidelines made or approved by the EPA under section 105 of the Contaminated Land Management Act 1997 (CLM Act), including any site investigations undertaken, and the subsequent report/s.*
    - *follow the processes outlined in State Environmental Planning Policy 55 - Remediation of Land (SEPP55), to assess the suitability of the land and any remediation required in relation to the proposed use.*

There geotechnical requirements have been addressed in this report by presenting:

- The results of a desktop study of existing information to characterise conditions
- Discussion and recommendations on geotechnical risks associated with the proposed landuse and recommendations for additional investigations.

2.0 Objectives

The objectives of the preliminary geotechnical assessment are to:

- Use published information and supplied geotechnical reports to assess likely subsurface conditions.
- Assess the risk of significant geotechnical constraints to the proposed redevelopment.
- Make recommendations for additional geotechnical investigations required to inform the proposed redevelopment of the Study Area.

3.0 Sources of information

The following sources of information were used in the preliminary geotechnical assessment:

- Sydney 1:100,000 Geological Series Sheet 9130 Edition 1 1983 NSW Department of Mineral Resources
- Sydney Soil Landscape Series Sheet 9130 (4th Edition)
- Jeffery and Katauskas Pty Ltd (J+K) 2010. Geotechnical Report for Riverwood North Renewal Project at Washington Avenue, Riverwood, NSW, Reference 24375VTrpt, dated 8 November.

No additional, site-specific information has been provided for the current proposal.

4.0 Site description

4.1 4.1 Study Area

The Riverwood Estate State Significant Precinct (the Study Area) is an area of 30ha and is located within the Canterbury Bankstown LGA. The Study Area contains a large area of government-owned land (16.7ha owned by LAHC) and is of state importance in achieving key government policy objectives, particularly renewing social housing and increasing housing supply.

The Study Area is bound by Belmore Road to the east, the M5 Motorway to the north, Salt Pan Reserve to the west and Killara Avenue to the south.

The Study Area comprises 1,019 social housing dwellings (1,017 owned by LAHC and 2 by the Aboriginal Housing Office [AHO]), 60 private dwellings and land owned by Canterbury Bankstown Council. A diverse range of dwelling types, including three-storey walk-up apartment buildings, studio apartments, free-standing cottages and nine-storey apartment buildings is located within the study area.

An overview of the Study Area identification details is provided in **Table 1**.

Table 1 Study Area Identification

Item	Description
Local Government Authority (LGA)	Canterbury-Bankstown (former Canterbury)
County	Cumberland
Parish	St George
Site Elevation	Ranges from 4 – 27 m AHD
Distance from Sydney CBD	Approximately 16 km
Current Land Zoning	Canterbury Local Environmental Plan (LEP) 2012: predominantly Zone R4 Residential (high density), with an area of Zone R3 Residential (medium density) in the west.
Current Land Use	Residential, commercial, and vacant properties
Proposed Land Use	Residential (medium and high density)
Study Area Location	**Figure 1**

Notes: AHD: Australian Height Datum

Figure 1 Riverwood Study Area (Source: LAHC)

4.2 Topography and drainage

The Study Area lies on gently undulating ground on the eastern flank of the Salt Pan Creek valley. Ground elevations range from about RL 4 m to RL 27 m AHD. The land generally slopes to the west, towards Salt Pan Creek which lies about 300 m west of the Study Area.

Salt Pan Creek, which is aligned north-south, is surrounded by wetlands along its eastern and western edges. Most of the wetland on the eastern side of the creek near the Study Area was removed in the development of Salt Pan Creek Tip.

Most of the wetland is saline, with areas of freshwater wetland and forested wetland. Salt Pan Creek meets the Georges River about 3 km from the Study Area. A lake associated with Salt Pan Reserve lies about 95 m north-east of the Study Area, understood to be used as a wetland area and bird habitat.

5.0 Geotechnical conditions

5.1 Geology

The Sydney 1:100,000 Geological Series Sheet 9130 indicates the Study Area is mainly underlain by Triassic Ashfield Shale (Rwa) of the Wianamatta Group. The Ashfield Shale is described as black to dark grey shale and laminite. The westernmost portion of the Study Area is described as Quaternary Alluvium (Qha) and to the west of that an area of Man-made Fill and Quaternary Alluvium (mf/Qha) is shown. The geological sheet describes the alluvium as comprising silty to peaty quartz sand, silt and clay with ferruginous and humic cementation in places and common shell layers.

The filled area shown on the geological sheet actually extends closer to the western boundary of the Study Area than is shown, as records and the landform indicate that immediately to the west of the Study Area was formerly the Salt Pan Creek Tip. Materials in this area are likely to comprise dredged estuarine sand and mud, demolition rubble, industrial and household waste, overlying the alluvial sediments.

5.2 Soil Landscape

The Sydney Soil Landscape Series Sheet 9130 (4th Edition) indicates the Study Area is mainly underlain by Blacktown unit (bt), described as gently undulating rises on Wianamatta Group shales and Hawkesbury shale. There are generally broad rounded crests and ridges with gently inclined slopes that are usually flatter than 5 degrees. Soils are shallow to moderately deep (<100cm) on crests, upper slopes and well drained areas. Soils are deep (150-2300 cm) on lower slopes and in poorly drained areas. Limitations of the soils of the Blacktown unit include:

- Moderate reactivity, highly plastic subsoils that are poorly drained.
- Moderate erodibility
- Locally sodic and saline.

The lower lying western and northern edges of the Study Area are underlain by Birrong unit (bg), described as level to gently undulating alluvial floodplain draining Wianamatta Group shales. There are generally broad flat valleys with local relief to 5 m and slopes less than 3 degrees. Soils are deep (>250 cm). Limitation of the soils of the Birrong unit include:

- Moderate to slight reactivity. Potential movements are offset by poor drainage and high salt concentrations which tend to reduce soil moisture changes.
- Upper soils have low erodibility, but subsoils are highly erodible and can be dispersive.
- Sodic and saline.

5.3 Acid sulfate soils

Soils within the Study Area are predominantly classified as Acid Sulfate Soil (ASS), Soil Class 5 (indicating no known risk of ASS being present). A small portion of the Study Area along the western boundary (limited to a portion of two AHO properties on Kentucky Road) appears to fall within Soil Class 2 (AECOM, 2017). Works below natural ground surface or works which may lower the water table present an environmental risk in Soil Class 2 areas.

5.4 Interpreted subsurface conditions

The J+K (2010) geotechnical report presents information on ground and groundwater conditions from the adjacent Riverwood North Renewal Project at Washington Avenue, Riverwood, to the north and north-east of the Study Area. The ground and groundwater conditions in the Study Area are expected to be similar to those on the adjacent site.

In general, a fill layer of variable thickness, overlying residual clay soils, overlying shale bedrock is expected. An exception may be the western portion of the Study Area adjacent to Salt Pan Creek

Reserve, where alluvial deposits may be encountered, between a fill layer (if present) and the residual soils or bedrock.

5.4.1 Ground profile

Based on the J+K (2010) boreholes and laboratory test results a preliminary geotechnical model has been developed and is presented in Table 2.

Table 2 Preliminary Geotechnical Model

Geotechnical Unit	Material Description	Possible Range of Unit Thickness (m)
Unit 1 – Fill	Variable materials, predominantly Silty Clays • Variable compaction, undocumented • likely to be pockets of waste material	0.1 to 2
Unit 2 – Residual Soil	Silty Clay medium and high plasticity stiff to hard consistency	1 to 3.5
Unit 3a – Poor Quality Shale	Shale • Shale Class V and IV • extremely and highly weathered • extremely low to medium strength • highly fractures and fragmented with clay seam	2 to 6.5+
Unit 3b – Better Quality Shale and Sandstone	Shale and fine grained Sandstone • Shale Class III or better • moderately weathered to fresh • low to high strength	Likely to be of considerable thickness or to be underlain by similar or better quality Hawkesbury Sandstone

Notes to Table 2:

- Unit thickness estimates are based on information from an adjacent site and should not be assumed to represent the maximum or minimum thickness on the Study Area.
- A geotechnical unit for alluvium which may be present at low elevation on the western boundary is not shown in the table as it was not encountered in the J+K (2010) investigation and hence there is no information on the nature of such materials if they exist in the Study Area.
- Rock classes are based on Pells et al. (1998).

5.4.2 Groundwater and permeability

As the site is relatively low lying and borders Salt Pan Creek, a standing regional groundwater table is likely to be encountered within the bedrock profile. In addition, localised perched groundwater is likely to be encountered within Unit 1 Fill and at the interface between Unit 2 Residual Soil and the underlying Unit 3 bedrock. J+K (2010) encountered groundwater in some boreholes at depths ranging from 2 m to 7.5 m.

The typical site materials are likely to be fine grained and of low permeability. In the bedrock, the permeability of defects such as joints and bedding partings will be dependent on the nature of the defects but is likely to be significantly higher than the intact rock.

6.0 Discussion and recommendations

6.1 Geotechnical feasibility and constraints

In general, the anticipated ground conditions do not pose significant risks to the feasibility of the proposed development. Geotechnical aspects relevant to the site should be manageable in design and with good construction practices.

For the proposed development, we expect that the design elements that will be impacted by geotechnical conditions will include:

- Temporary and permanent unsupported excavations
- Retention systems for temporary and permanent excavations
- Slabs on ground
- Building foundations
- Ancillary structure foundations (e.g. light poles, sign poles, fences)
- Pavements.

Table 3 summarises potentially adverse geotechnical conditions that may be encountered in the Study Area.

Table 3 Potentially adverse ground conditions

Geotechnical Condition	Anticipated Site Condition
Fill impacting on excavations. retaining walls, building foundations, and pavements	Variable depth and composition of Fill expected.
Potential for soft or compressible alluvium	Limited to the western boundary of the Study Area, if present
Moderate and highly reactive residual soil, susceptible to shrink swell volume change with variation in moisture content	The high plasticity clays in the residual soils are likely to be moderately and highly reactive. Linear Shrinkage values of 12% to 16.5% from the J+K (2010) investigation indicate reactive soils.
Saline or Sodic soils	Highly saline or sodic soils may be found locally across the study area. On the western and northern edges such soils may be more widespread
Erodible and Dispersive soils	Highly erodible and dispersive soils may be found across the study area.
Low subgrade California Bearing Ratio (CBR) may require subgrade replacement or improvement	CBR tests on residual soils from J+K (2010) investigation of 2% and 3.5% indicate low CBR value.
Groundwater levels impacting on basement excavations, retaining walls and ground slabs. **Risk that tanked basements may be a DPI Water condition of approval.**	Groundwater monitored at 2 m to 7.5 m depths
Poor quality bedrock limiting design parameters for footings	Shale bedrock may be weathered to considerable depth

The following sections present discussion and recommendations on how the expected subsurface conditions may be managed in design and construction.

6.2 Hydrogeological impacts

J+K (2010) encountered groundwater in some boreholes at depths ranging from 2 m to 7.5 m. Buildings with deep excavations for car park basements are likely to intersect the water table and will require temporary dewatering during construction. In accordance with the NSW Aquifer Interference Policy, temporary dewatering should be licenced and conducted under a groundwater management plan designed to manage groundwater extraction, groundwater discharge and potential impacts to surrounding infrastructure and the environment.

DPI Water generally does not support the concept of mechanical pumping to maintain long term dry conditions. Groundwater studies may be able to demonstrate that permeability is sufficiently low that groundwater conditions are not significantly impacted by drained or partially drained basements. However, if DPI Water impose a no pumping condition on this development then buildings intersecting the water table would have to be designed to eliminate groundwater seepage and manage against the effect of groundwater pressures. For tanked basement systems, the lowest basement floor should be designed for full hydrostatic uplift water pressures, corresponding to the design groundwater level or flood level.

Long term deep excavations that intersect the water table may cause localised changes in the groundwater flow direction and if not constructed with sufficient drainage, groundwater mounding may be created as the basements forms a local hydraulic barrier. It is expected that the groundwater flow direction is towards Salt Pan Creek. Buildings and other structures with deep excavations should be constructed to mitigate the influence on the localised groundwater flow direction. Design options include constructing drainage layers, consisting of permeable gravel beneath buildings. Within the drainage layer it is common to install porous drainage pipe to assist drainage and allow for maintenance such as periodic flushing.

Groundwater within the Wianamatta Shale is typically saline. In Western Sydney the problems associated with saline water are well known and Councils often recommend salinity investigations to identify the risks in developing a site as a result of saline conditions. Increased urbanisation can result in saline groundwater reaching the ground surface causing land salinization and salt scalds if not properly managed. In addition, corrosion tolerant building materials should be selected to mitigate the impacts of urban salinity. Salinity investigations are typically conducted in accordance with the Western Sydney Regional Organisation of Councils (WSROC) salinity code of practise and Site Investigations for Urban Salinity, published by the Department of Land and Water Conservation. The salinity investigation is the main input into preparing a salinity management plan for the development.

6.3 Temporary unsupported excavations

Unit 1 Fill is likely to be variable and may not have been placed in a controlled manner and compacted. Hence, while fill may stand at relatively steep batters for short periods of time, it would typically be cut at flatter batters than stiff residual soils. Unit 2 Residual soils are generally likely to be stiff and should stand at relatively steep batters for short periods of time when unsaturated.

Temporary and permanent excavations in fill and natural soils should be practicable where there is sufficient room to adopt batters or benching. From a geotechnical perspective; temporary batters would typically be cut up to 1.5H:1V and permanent batters up to 2H:1V in stiff ground above the groundwater table and where they are not subject to significant surcharge loads.

In rock, steeper temporary batters may be practicable, depending on the depth of excavation, rock quality and the nature of defects. In Unit 3a poor quality Shale batters may have to be similar to those adopted for the Unit 2 Residual Soils. In better quality Unit 3b Shale and Sandstone, vertical cuts may be possible. However, relatively low angle joints are common in Ashfield Shale and for deep basement excavations shoring is often taken to the base of excavation to reduce the risk of large wedge failures which have been described in historical records of shale quarries.

6.4 Retention systems

Retaining walls will be required where there is insufficient room for form unsupported batters or where surcharge loads are applied near the crest of cut batters. Various retention systems should be suitable for the expected ground conditions including:

- L-shaped cast in place walls where there is sufficient room to cut temporary batters to allow the wall footing to be formed.
- Bored soldier piles with timber infill panels for temporary support or shotcrete for either temporary or permanent support. Where excavation depths exceed cantilever spans for soldier pile temporary anchors may be required until propping from floor slabs is effective. Drainage can be installed behind such walls and hence they can be designed as drained.
- Contiguous bored piles designed to resist hydrostatic pressures.
- Soil nail walls with strip drains to relieve hydrostatic pressure and shotcrete facing.

Conventional open bored piles or continuous flight auger (CFA) piles should be practicable for piled retaining walls. For open bored piles, provision would need to be made to effectively clean the pile shaft and base and to dewater the piles before placing concrete.

6.5 Slabs on ground

It will be necessary to obtain relevant approvals to dispose of groundwater seepage off site. Alternatively, basements could be tanked, with retaining walls and slabs designed to resist uplift pressures.

Slabs on ground should be able to be adopted and designed as drained, if effective drainage systems are installed and maintained. Groundwater inflows are likely to be relatively minor and should be able to be controlled by pumping from sumps.

6.6 Building and ancillary structure foundations

6.6.1 Shrink swell potential

The classification of individual lots with respect to AS2870-2011 Residential slabs and footings will depend on factors such the presence of fill, nature of the soils, depth to bedrock and groundwater and the nature of vegetation and its proximity to structures. Based on the likely properties of the Unit 2 Residual Soil and depth to bedrock, we would expect that calculated characteristic surface movements may place sites within the Study Area within the range Class ‘M’ to Class ‘H2’.

6.6.2 Salinity and erosion potential

Saline and sodic soils may be encountered locally across the study area. They should be manageable by normal good durability design for concrete and steel in contact with the ground.

Erodible and dispersive soils may be encountered across the study area. They should be manageable during construction using normal good sediment control and with normal good, permanent surface and groundwater drainage design.

6.6.3 Footing types

For relatively lightly loaded structures it may be practicable to adopt shallow footings such as pad, strip or raft footing systems bearing on Unit 2 Residual Soil or Unit 3a Shale. However, where the depth to bedrock or excavation levels vary, the potential for differential ground movements should be considered and preference given to footings taken to a uniform bearing stratum.

For heavily loaded and/or settlement sensitive structures footings taken into the less weathered Unit 3b Shale and Sandstone should be adopted. This is likely to require piles of which open bored or CFA should be practicable types.

6.7 Pavements

Existing Unit 1 Fill is unlikely to be suitable as pavement subgrade unless assessed by sampling and testing and re-compacted. The Unit 2 Residual Soils are likely to have relatively low CBR and/or high CBR Swell.

A capping layer of higher CBR material such as well-graded crushed rock or in-situ material treated with lime or cement is likely to be required to improve the subgrade such that a CBR value of at least 3% can be adopted.

6.8 Further investigations

Information on subsurface conditions is limited to the report for the site to the north and north-east of the Study Area. To assess whether the inferred conditions presented in this preliminary geotechnical assessment are valid we recommend further intrusive investigations. The purpose of the additional investigations should be to extend information on subsurface conditions towards the western and southern boundaries of the site. In particular, assessing whether any landfill and/or alluvium extend on to the Study Area should be an objective of further studies.

About 6 to 10 boreholes distributed across the Study Area should provide sufficient information for concept and preliminary design. Allowance should be made to drill boreholes to a depth of at least 10 m with coring in bedrock. Sampling and testing of bulk samples from pavement subgrade level should also be allowed from these borehole locations.

For detailed design of medium and high-density residential buildings, further investigations will be required, with cored boreholes taken to below basement levels at each specific site.

If new road layouts or reconstruction of existing roads are required pavement investigations such as core holes and/or test pits will be required, with allowance for laboratory CBR tests.

7.0 Important information about this geotechnical report

Client details, scope and reliance

AECOM has prepared this report for the sole use of the Client and for a specific purpose, each as expressly stated in the report. No other party should rely on this report without the prior written consent of AECOM. AECOM undertakes no duty, nor accepts any responsibility, to any third party who may rely upon or use this report. This report has been prepared based on the Client's description of its requirements and AECOM's experience, having regard to assumptions that AECOM can reasonably be expected to make in accordance with sound professional principles. AECOM's findings represent its reasonable judgment within the time and budget context of its commission and utilising the information available to it at the time.

No section or element of this report may be removed, reproduced, electronically stored or transmitted in any form by parties other than those for whom the report has been prepared without the written permission of AECOM. All sections in this report must be viewed in the context of the entire report/document including, without limitation, any assumptions made and disclaimers provided. No section in this report may be excised from the body of the report without AECOM's prior written consent.

Standard of care

AECOM has prepared this report using the standard of reasonable skill, care and diligence required of a consultant performing the same or similar Services. The report should be read in full. No warranty, expressed or implied, is made as to the professional advice included in this report.

Data sources

AECOM may have relied on information provided by the Client and third parties (Information Providers) to produce this report and arrive at its conclusions. AECOM has not verified information provided by the Information Providers (unless specifically agreed as part of AECOM's scope of work) and we assume no responsibility and make no representations with respect to the adequacy, accuracy or completeness of such information. AECOM assumes no responsibility for inaccuracies in reporting by the Information Providers including, without limitation, by the Client's employees or representatives or for inaccuracies in any other data source whether provided in writing or orally used in preparing or presenting the report.

Variability in conditions and limitations of data

Subsurface conditions are formed through a variety of natural processes and can be altered by human activities. The behaviour of the ground, groundwater and contaminants are complex and conditions can vary across a particular site. As a result, subsurface conditions cannot be exhaustively defined by investigations at discrete locations. Therefore, it is unlikely that the results and assessments expressed in this report will represent conditions at any location removed from the specific points of sampling. The precision with which conditions can be inferred depends largely on the uniformity of subsurface conditions and on the frequency and method of sampling as constrained by factors such as project budget and time limitations and physical constraints.

Furthermore, subsurface conditions can change over time, which should be considered when interpreting or using the data within this report.

Verification of opinions and recommendations

The opinions and recommendations in this report apply to the proposed development and the site existing at the time of our investigation and cannot necessarily apply to changes in the proposed development or site changes of which AECOM is not aware and has not had the opportunity to evaluate. Our recommendations should be considered to be preliminary and subject to verification during project implementation. If conditions encountered at the site are subsequently found to differ significantly from those anticipated, AECOM must be notified and be provided with an opportunity to review the recommendations.