Appendix F

Flood impact assessment

Memorandum

ARUP

To	Edify Energy Pty Ltd	Date	7 March 2018
Copies	Kellie Charlesworth Amy Flinn	Reference number	254776
From	Gelareh Khakbaz Ivan Varga Sampedro	File reference	Flood_Assessment_memo_180307.docx
Subject	Darlington Point Solar Farm - Flood Impact Assessment		

1 Scope of this document

This memo documents the flood impact assessment prepared for the proposed solar farm at Darlington Point. The purpose of this study is to support the EIS application for the proposed solar farm by providing existing and post-development flood levels and assess current and future flood risks.

2 Background

Edify Energy Pty Ltd has commissioned Arup to determine existing flood behaviour for the location of the proposed Darlington Point solar farm. The proposed solar farm is to be located approximately 7.5 km south east of the township of Darlington Point within the Murrumbidgee Local Government Area in western NSW (Figure 1).

The proposed site is located on the Murrumbidgee River floodplain and is generally flat and the soil is high in clay content. The proposed site is located approximately 1.6 km south of the Murrumbidgee River at its closest point. A flooding assessment was required by the Secretary's Environmental Assessment Requirements (SEARs) for the project.

Whilst anecdotal evidence and historic flood mapping exists for the site, there is no known previous flood modelling work available. However, it is understood Murrumbidgee Council has commissioned a consultant to undertake a comprehensive flood study of Darlington Point and the surrounding floodplain. This study is currently ongoing, however, it is understood that the hydraulic model extent is unlikely to cover the floodplain where the proposed solar farm is to be designed.

As such, the flood assessment presented in this memo consists of a desktop hydraulic analysis based on historical flood evidence sourced from the Murrumbidgee River Flood Atlas provided by OEH, pers com 2017) and existing ground survey of the site to estimate flood levels and velocities. The Flood Atlas depicts the estimated flood extent that was experienced by local residents during the

August 1974 flood event, which has been estimated to be around a 90 year ARI flood event (Appendix C). Ground survey was undertaken and utilised to estimate flood levels within the site.

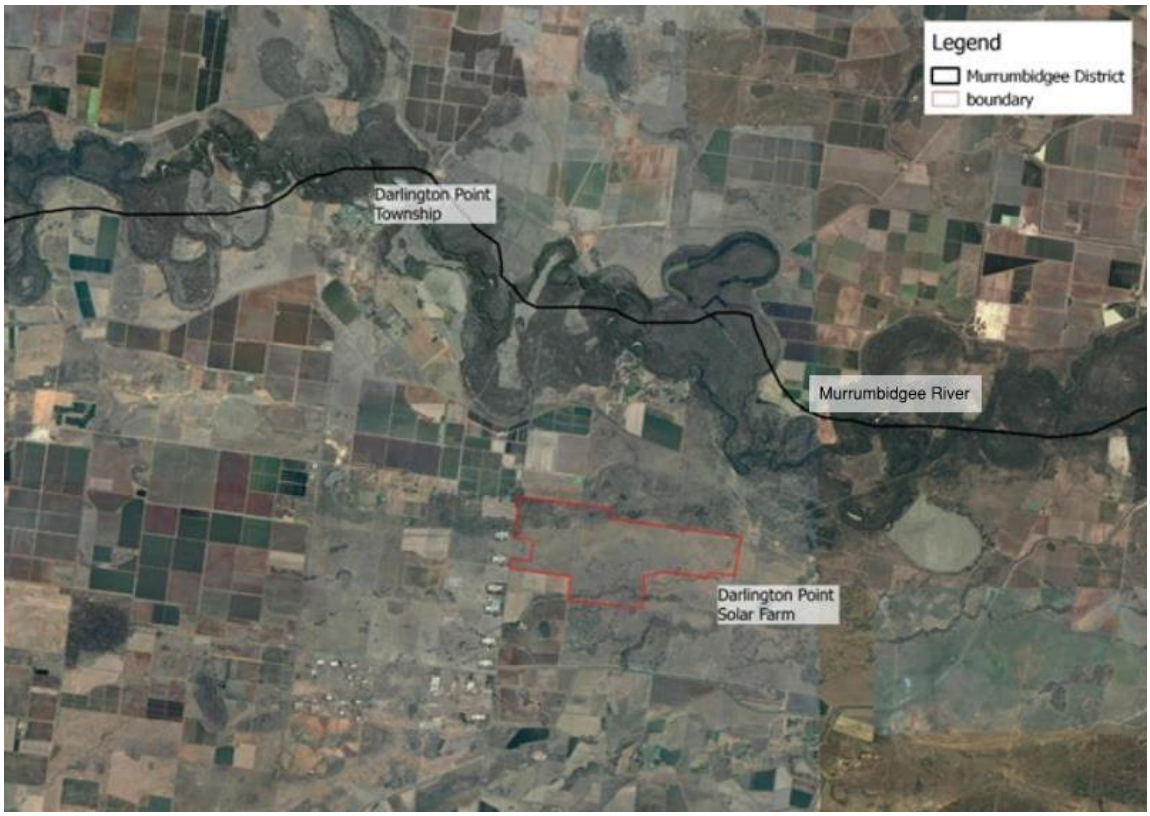


Figure 1 Location of proposed Solar Farm at Darlington Point

3 Objectives of this assessment

The primary objective of this study is to assess flood behaviour change within the Darlington Point Solar Farm site and adjacent areas as a result of the proposed development. As part of the assessment the following tasks have been undertaken:

- Review of relevant information and reports provided by Edify / Arup;
- Source Murrumbidgee River Flood Atlas information for 1974 flood event near Darlington Point;
- Estimate flood levels based on the 1974 flood extents and current ground survey (existing scenario);
- Estimate flow and velocities for the pre-development scenario for the 1974 flood event for a number of cross sections across the site, using Manning's equation;
- Estimate flood levels and velocities for the post-development scenario for the 1974 flood event by calculating hydraulic energy losses associated to the obstruction of flow caused by the development; and
- Map and tabulate results and findings.

4 Flood Assessment

4.1 Available data

The data used in producing the flood impact assessment is summarised below:

- An image of the August 1974 flood event (provided by the Office of Environment and Heritage, OEH) depicting the approximate flood extent across the Murrumbidgee River floodplain. The image originates from the Murrumbidgee River Flood Atlas (Figure 2). The 1974 flood is estimated to have a probability of a 90 year ARI flood event;
- Ground survey (July 2017) for the site; and
- The proposed layout of the solar modules and other site layout details (refer to Appendix B).

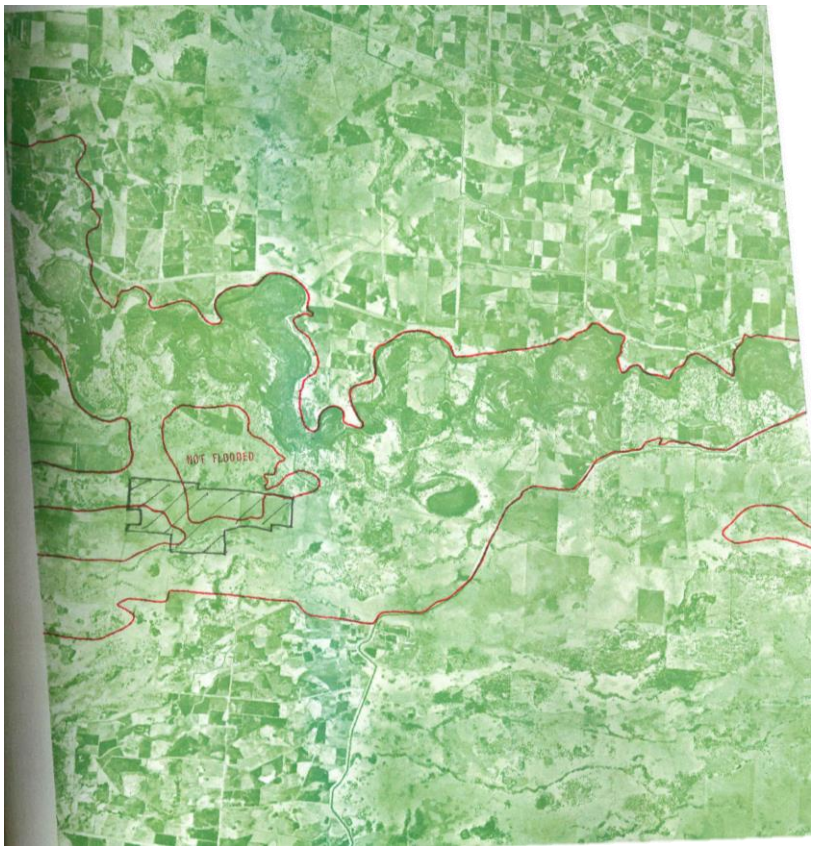


Figure 2 Murrumbidgee River hand-drawn flood atlas with extents for the 1974 flood event (Source: OEH, 2017)

4.2 Methodology

4.2.1 Pre-development scenario

In order to derive flood levels for the 1974 flood, the extents of the flood were overlayed on top of the existing site ground survey. Corrections to the flood extent data were made in areas where flood extents were not consistent with ground levels (either too low or too high, depending on the

undulating topography). A flood depth map across the site was estimated by subtracting the flood level surface from ground survey levels.

Flow velocities for a number of sections across the site were estimated using Manning's equation for uniform flow:

$$\mathbf{u} = \frac{\mathbf{1}}{\boldsymbol{n}} \boldsymbol{R}_{\boldsymbol{h}}^{\frac{\mathbf{2}}{\mathbf{3}}} \mathbf{S}^{\frac{\mathbf{1}}{\mathbf{2}}}$$

where u is velocity, n is Manning's roughness coefficient, R_h is the hydraulic radius and S is the slope.

Ground survey and estimated levels were used for determining the hydraulic radius and slope for each cross section. Figure 3 shows the location of cross sections for which the calculations of velocity was performed.

The site is generally covered with dense, low to medium grass. As such, a Manning's n value of 0.04 was adopted in the calculations as per recommendations in Project 15 of AR&R 2016.

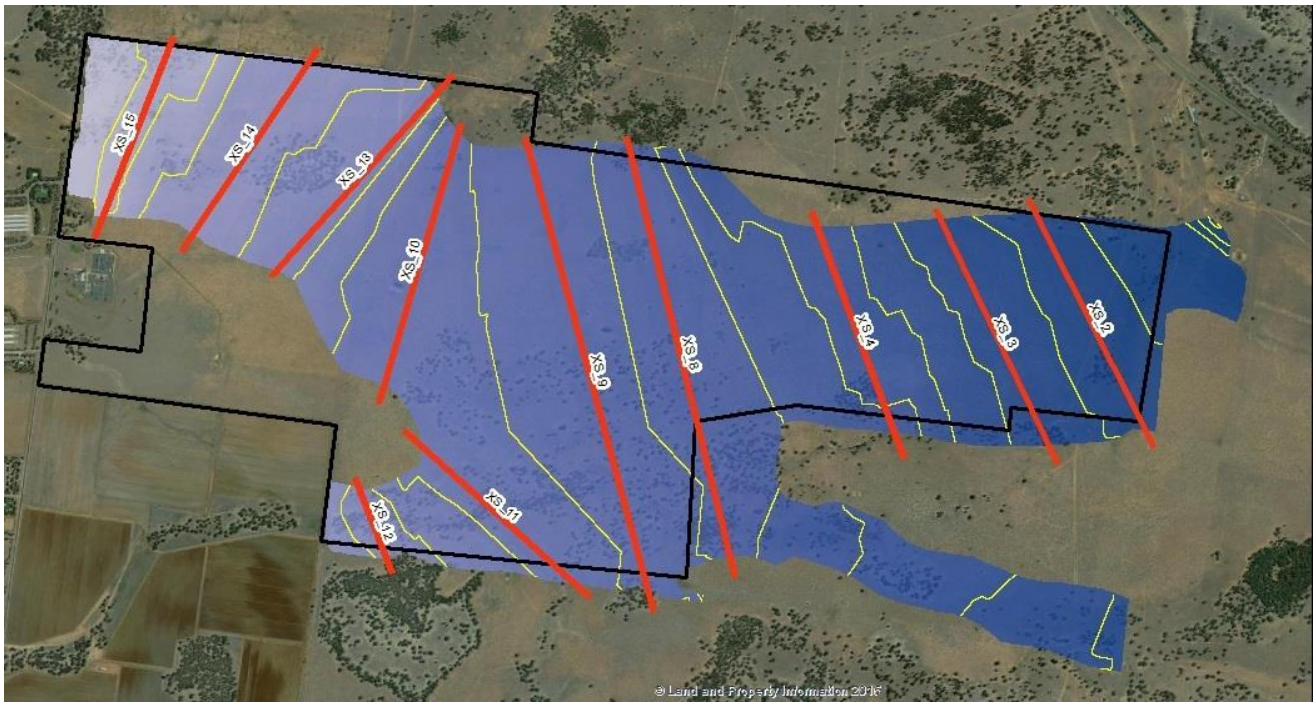


Figure 3 Location of flow cross sections

4.2.2 Proposed post-development scenario

The site layout (Appendix A) and solar unit specifications (Appendix B) were used to determine the post development site flooding conditions for the 1974 flood event. Individual solar unit and inverter station piles were treated as flow obstacles through the site during flooding from the Murrumbidgee River. Inverter stations will be placed on piles above flood level and determined during detailed design through a revised flood assessment. The proposed substation and O&M facility location is outside of the known flood prone area (Figure 3) and hence was not included in the modelling.

The hydraulic energy losses that would be experienced in the site as a result of the obstruction to the flow by the piles have been calculated utilising theory of energy losses from bridge piers as documented in the US Federal Highways Administration (US FHWA, 1978) document. The solar panel piles were assumed to have similar behaviour as bridge piers, thus adopting the same methodology has been deemed adequate. The head loss through the piles can be estimated by:

$$\Delta h = \Delta K_p \frac{V^2}{2g}$$

where Δh is difference in water surface elevation, ΔK_p is incremental backwater coefficient for piers, v is the averaged velocity at the cross section (m/s) and g is acceleration of gravity.

This equation calculates changes in kinetic energy using the velocity head at each cross section (determined in existing scenario) to determine changes in flood level.

5 Results

5.1.1 Pre-development scenario

Figure 4 depicts the flood depth across the site for a 90 year ARI flood event based on 1974 flood event. Flood depth across the site for the existing case is generally less than 0.25m. Results show localised areas with flood depths of up to 0.50m. The maximum depth is obtained in the southern portion of the site reaching 0.75m.

Velocity across the site ranges from 0.07 to 0.23 m/s.

5.1.2 Post development scenario

Changes in peak flood level at each cross section are presented in Table 1. It is noted that the predicted changes in flood levels due to the proposed development are less than 0.001m for the modelled scenario and therefore considered minor.

It is noted that debris dragged by floodwater may deposit or hit the boundary site fence, increasing the risk associated with blockage. However, the likelihood of debris being collected around the fence is relatively low, as floodwaters around the site are described to be of low velocities, hence a lower potential to drag physical elements that may be considered flood debris. Additionally, it is noted that high vegetation and trees are present in the floodplain upstream of the site, which may block debris transported by the river during flood events.

As a result, it is likely that no adverse flood impacts will occur on-site or on nearby properties as a result of the proposed development.

Memorandum

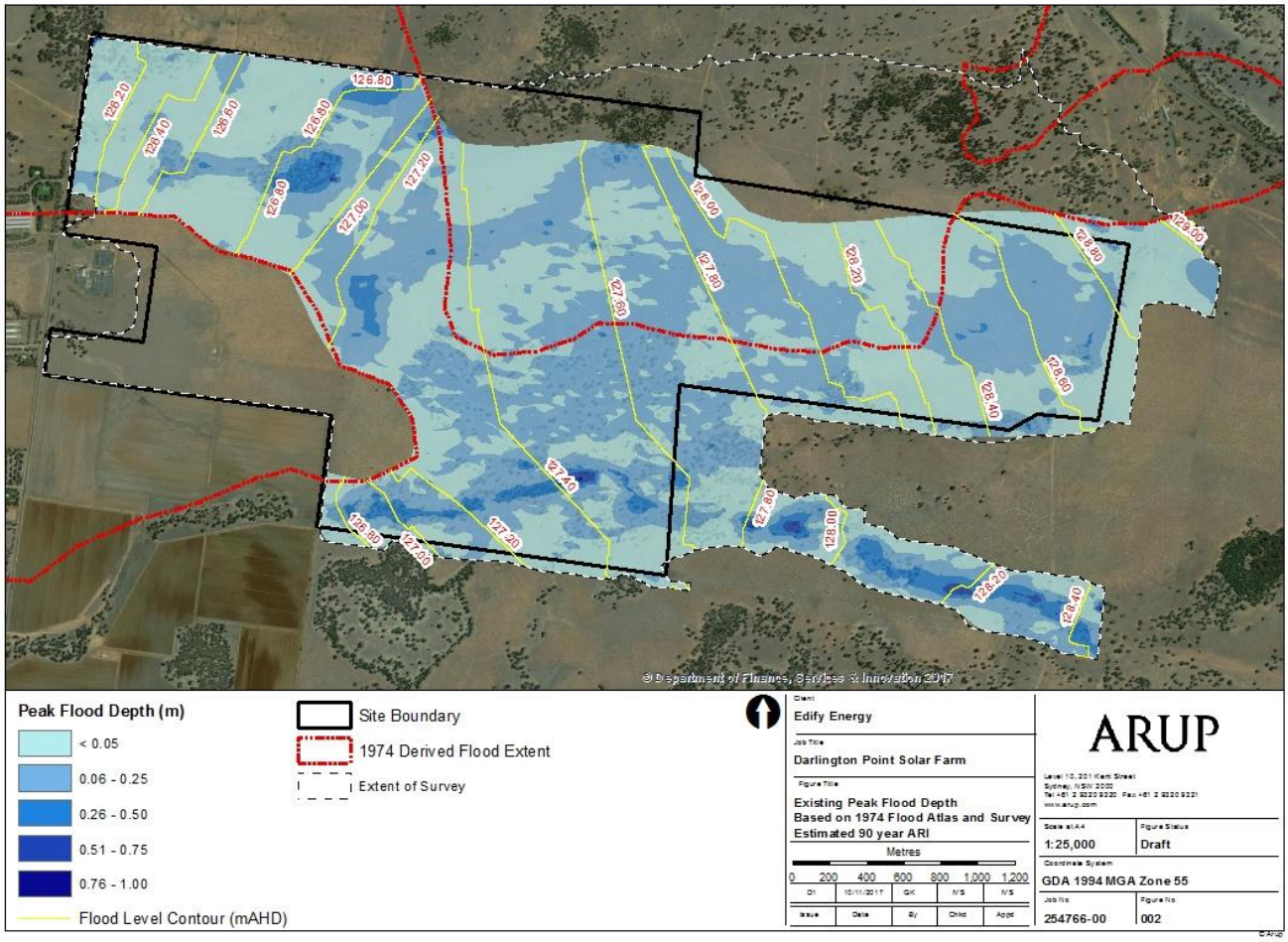


Figure 4 Pre-development peak flood depth - based on the 1974 flood atlas and 2017 ground survey

Table 1 Flood level for existing and post-development scenarios, and changes in flood level across the site

Location	Velocity (m/s)	Existing Case Average Flood Level (mAHD)	Post-development Average Flood Level (mAHD)	Changes in Flood Level (m)
XS_2	0.16	128.75	128.75	0.00003
XS_3	0.14	128.57	128.57	0.00002
XS_4	0.07	128.08	128.08	0.00002
XS_8	0.12	127.67	127.67	0.00001
XS_9	0.11	127.53	127.53	0.00001
XS_10	0.14	127.36	127.36	0.00003
XS_11	0.10	127.29	127.29	0.00000
XS_12	0.23	127.12	127.12	0.00003
XS_13	0.14	127.01	127.01	0.00003
XS_14	0.17	127.00	127.00	0.00003

Location	Velocity (m/s)	Existing Case Average Flood Level (mAHD)	Post-development Average Flood Level (mAHD)	Changes in Flood Level (m)
XS_15	0.18	126.58	126.58	0.00005

5.1.3 Flood immunity

The detailed design of the solar farm facilities including the substation and O&M facility will need to meet relevant design criteria, including flood immunity. As presented in Appendix A, the proposed substation and O&M facility location is located outside the flood prone area presented in Figure 4. As such, these areas are deemed flood free in a 90 year ARI flood event.

6 Conclusion

A flood impact assessment was undertaken to determine the flood behaviour across the proposed Darlington Point Solar Farm. The desktop study was based on the existing site survey data and historical flood information from the 1974 flood event which has been estimated to have a probability of 90 year ARI flood event (OEH, 2017). The impact of the proposed solar farm development was determined using bridge pier backwater calculation theory.

The flood depth across the site for the existing scenario is generally around 0.25m with the maximum depth of 0.75m towards the northwest of the site.

The results of the analysis found that post development scenario the increase in flood level compared to the pre development scenario is negligible and less than 0.001m.

References

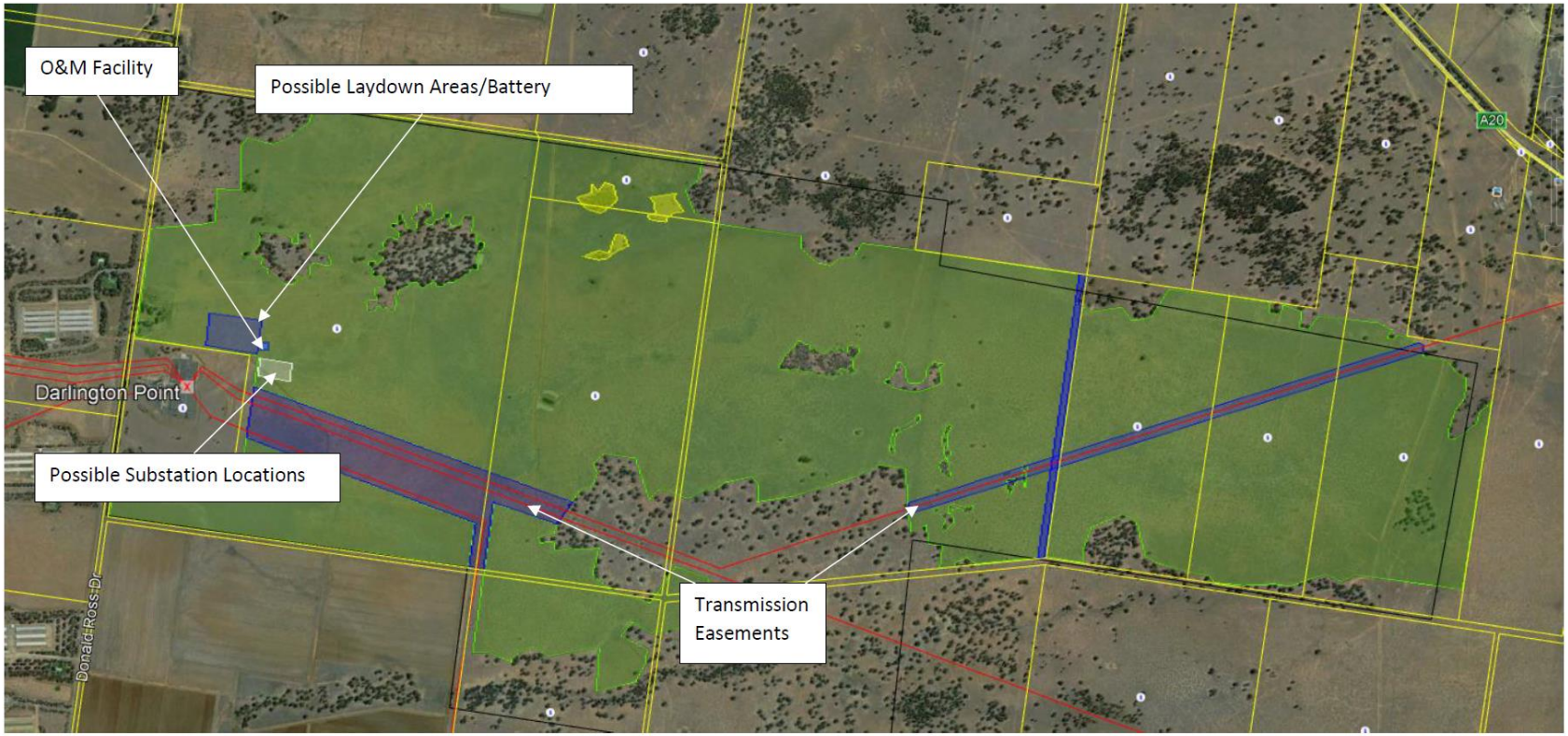
Arup (April 2017) Preliminary Environmental Assessment

Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors), 2016, Australian Rainfall and Runoff: A Guide to Flood Estimation, Commonwealth of Australia

US FHWA (1978) Hydraulics of Bridge Waterways. US Federal Highway Administration (FHWA)

OEH, pers com 2017. Murrumbidgee River Flood Atlas (See Appendix C)

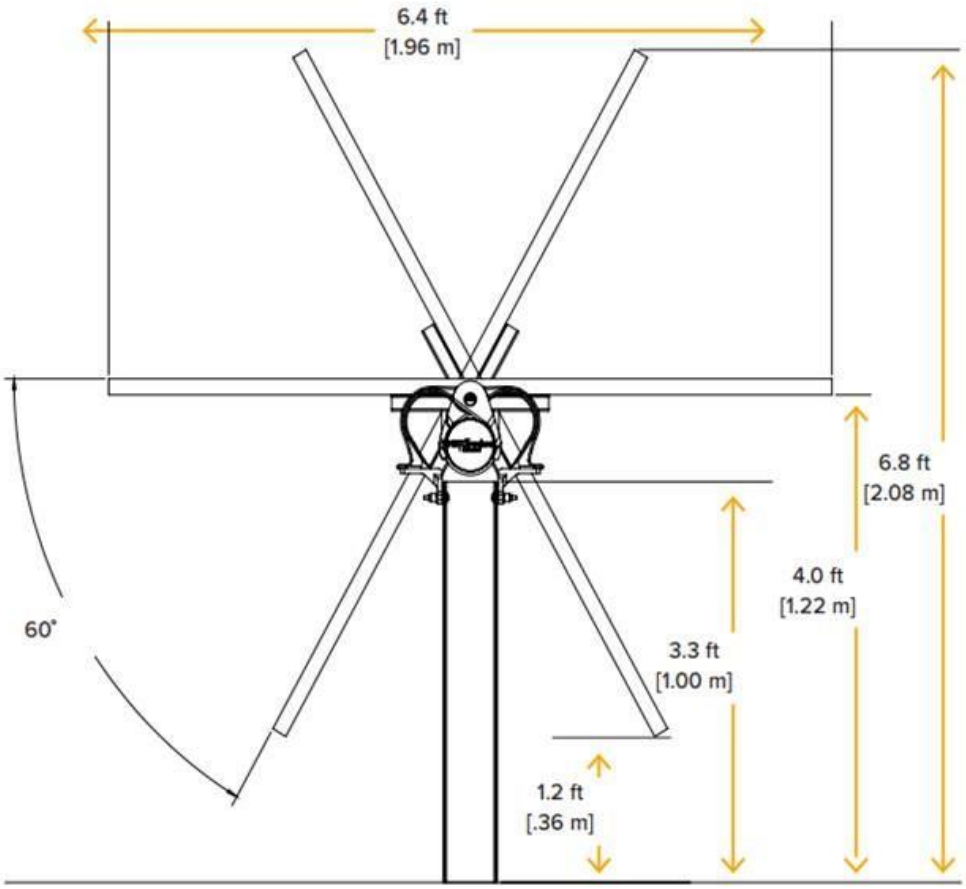
Appendix A Site layout from Edify Energy



Notes:

- The area highlighted in green on the proposed array are consisting of arrays, inverters and internal access roads. This is the maximum area and a firebreak/buffer of 20m will be left between any retained vegetation and panels. Roads may be located in the buffer.
- The transmission line easement will not be used for panel inverters but access roads and buried cables will be routed through the easements.
- The yellow areas to the north are no go areas.
- Indicative locations have been shown but the assessment should allow these to be located elsewhere as not expected to effect the development impact.

Appendix B Typical solar unit specifications


6.4 ft
[1.96 m]
6.8 ft
[2.08 m]
4.0 ft
[1.22 m]
3.3 ft
[1.00 m]
1.2 ft
[.36 m]
60°

Appendix C Murrumbidgee River Flood Atlas (OEH pers com, 2017)

Ivan Varga Sampedro

From:	Leah Howell
Sent:	Friday, 7 April 2017 2:53 PM
To:	Ivan Varga Sampedro
Subject:	FW: Darlington Point Solar Farm - flood assessment
Attachments:	Murrumbidgee River flood atlas (1974 flood extent).pdf

Leah Howell
Senior Consultant | Environment and Resources
d: +61 2 9320 9323 m: +61 (0) 403 009 369

From: Steve Manwaring [mailto:Steve.Manwaring@environment.nsw.gov.au]
Sent: Friday, 7 April 2017 1:49 PM
To: Leah Howell
Cc: Peter Ewin
Subject: RE: Darlington Point Solar Farm - flood assessment

Hi Leah,
Thankyou for the docs.

I have attempted to locate the site boundary on the Murrumbidgee River flood atlas for the 1974 flood in the attached pdf (hatched in black). Assuming this is roughly correct you can see that sections of the site are shown to be flooded in the 1974 event. The 1974 event corresponds to a 60 yr ARI flood according to this atlas at Darlington Point (DP) but a more recent flood study done in 2009 for the DP levee design by Worley Parson (obo Murrumbidgee SC) has this event around the 90yr ARI level. For comparison the 2012 event corresponds to about a 70yr ARI event in the FFA of this same flood study. Unfortunately this flood study did not extend to the project site.

As you know Murrumbidgee Council are about to start a new flood study for DP using BMT WBM consultants who propose to develop a detailed TUFLOW 2D hydraulic model but again the study area does not extend to the site due to there being no known LiDAR data in this area. The FFA will also be updated as part of this study so this may impact on the design flood levels. Ideally, this flood model could be extended to cover the project site if extra LiDAR data (or detailed ground survey) was obtained.

Coincedentally, Narrandera SC recently completed a flood study (2015) associated with their levee upgrades using Lyall's and Assocociates Consulting Engineers. Below is a screen shot of the 100yr ARI flood extent map from the report but again it falls just short of the project site due to the lack of LIDAR data. It must be noted that since this study focused on Narrandera and historic flood marks were sparse in this area, this end of the model was not that well calibrated but as I understand it RMS are still using the data in the design of the Sturt highway upgrade between DP and Gillenbah. What it does show are some water surface elevation contors in mAHD adjacent to the site boundary I believe. If you wished to have access to this report you will have to approach Narrandera SC.

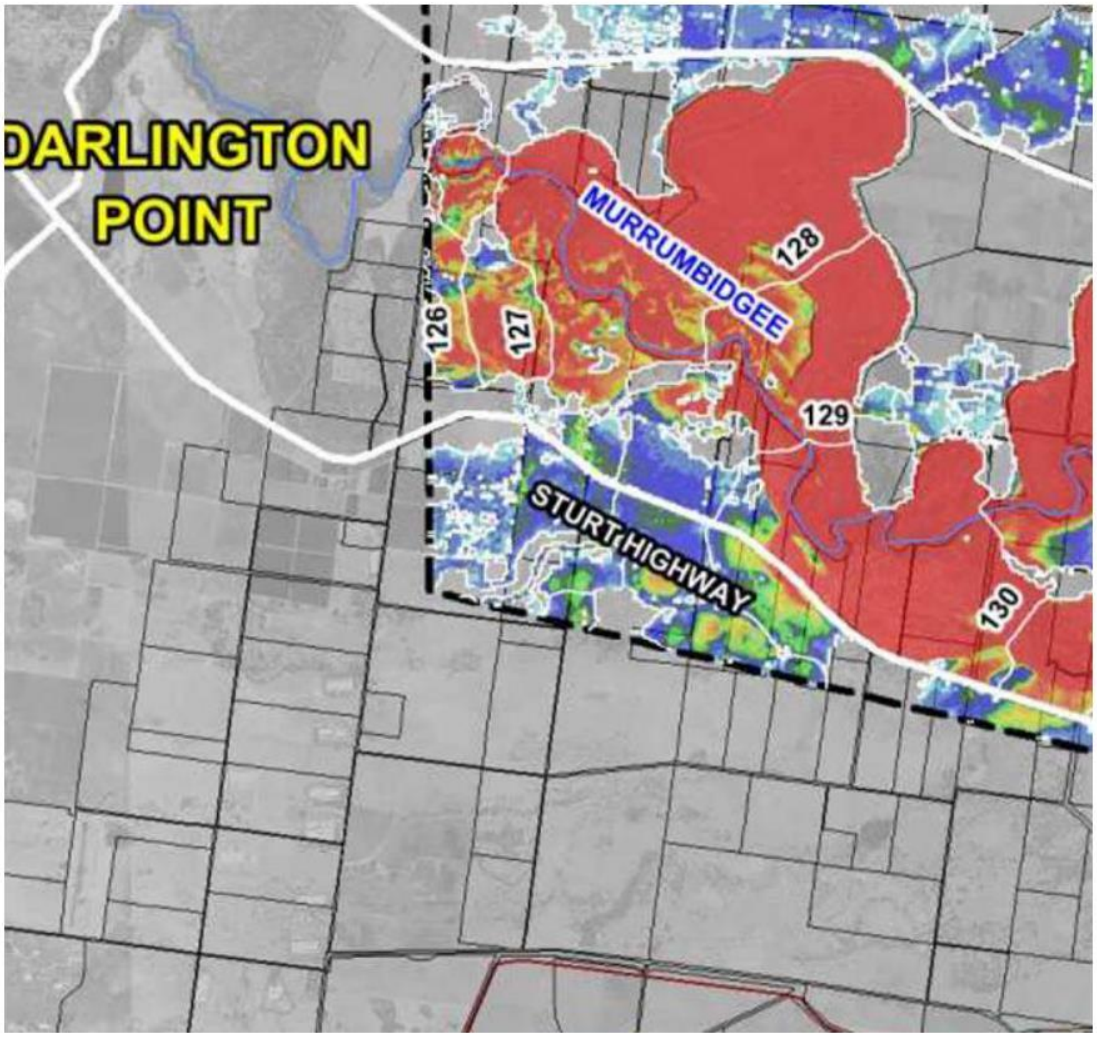
I am not currently in a position to provide you with an indication of what level of flooding assessment that is needed in this case. Once I receive a request from DP&E for the SEAR's with the associated documentation I will make an assessment. However, for this size and scale of the project I would have thought that an assessment of the location and magnitude of flows traversing the site in major floods would be necessary as part of an impact assessment as well as being particularly useful for your client in the design of the infrastructure across the site.

Hope this helps.

Best Regards,

Memorandum

Steve



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NSW GOVERNMENT | Office of Environment & Heritage

From: Leah Howell [mailto:Leah.Howell@arup.com]
Sent: Friday, 7 April 2017 10:58 AM
To: Steve Manwaring <Steve.Manwaring@environment.nsw.gov.au>
Cc: Ivan Varga Sampedro <Ivan.Varga-Sampedro@arup.com>
Subject: Darlington Point Solar Farm - flood assessment

Hi Steve,

Thank you for getting in touch yesterday about the proposed Darlington Point Solar Farm.

2

Memorandum

The site is located around 10 km south of Darlington Point, adjacent to the TransGrid substation off Donald Ross Drive (see attached map).

We know that the site has been subject to flooding, however can't seem to locate any information about flood levels at the site.

Besides areas of dense vegetation and transmission easements, it is expected that most of the site will be developed. This is likely to comprise between 800,000 and 1,000,000 pv panels, installed in 5 MW arrays which would be spaced around 7-8 m apart.
A switchyard would also be established just outside the eastern fence of the TransGrid substation, and a security fence would be installed around the perimeter of the site. No earthworks, benching, or levelling, etc. is proposed.

I have attached some pics from another solar farm to give an idea about spacing of the posts.

Given the lack of data available for the site, we are keen to understand what level of assessment will be required in the EIS to assess the flood impacts of the project. We are also keen to better understand the flood levels to feed into the project design heights.

Any assistance with data or advice is much appreciated.

Kind regards,
Leah

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