

Appendix 6

Conceptual Flood Assessment Dated March 2011

Prepared by Gilbert and Sutherland

PLANS AND DOCUMENTS
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Queensland
Government



MORTONS
urbansolutions

PROJECT
**CONCEPTUAL FLOOD
ASSESSMENT
FLINDERS GROVE
UNDULLAH
QUEENSLAND**

PREPARED FOR
**PACIFIC INTERNATIONAL
DEVELOPMENT CORPORATION**

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SYNOPSIS This report describes the methodology and results of a flood assessment undertaken to quantify existing flood levels and constraints at the Flinders Grove site, and to examine the impacts resulting from proposed future mixed use development across the site, based on the current Concept Plan.

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SUMMARY

Pacific International Development Corporation (PIDC) commissioned Gilbert & Sutherland Pty Ltd (G&S) to prepare a conceptual hydrologic and hydraulic assessment to determine the flooding constraints to aid in the planning for future mixed use and residential development across the Flinders Grove site at Undullah, Queensland.

A hydrologic assessment was undertaken using the Rational Method and the Watershed Bounded Network Model (WBNM) to estimate peak flows along Undullah Creek and Woollaman Creek in the Western portion of the site and an unnamed tributary of Teviot Brook that drains the catchment containing the eastern portion of the site.

A combined 1D/2D flood model was developed for Undullah Creek and Woollaman Creek and the eastern catchment using the Deltares model for 1D/2D flood simulation 'SOBEK' to estimate existing local flood levels within the site and to estimate the hydraulic impacts of the proposed development, as described in the concept plan.

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1 Introduction

Pacific International Development Corporation (PIDC) commissioned Gilbert & Sutherland Pty Ltd (G&S) to prepare an assessment of existing flood constraints within the Flinders Grove site, in support preliminary planning for future residential and mixed-use development across the site. A preliminary analysis of the hydraulic impacts of the proposed development has also been carried out.

Located off Undullah Rd at Undullah, Queensland (as shown on Drawing No. 10511.1.1) the site comprises 22 allotments. Lot descriptions and ownership particulars are summarised below:

- Lot 78 on M33772 and Lot 81 on S311859 owned by Beaudesert Shire Council.
- Lot 2 on S31878, Lot 32 on S311402, Lot 3 on S311896, Lot 19 on S311970, Lot 74 on S312820, Lot 79 on S312955, Lot 80 on SL1163, Lot 42 on SL5873, Lot 200 on SP133189, Lot 30 on SP133190, Lot 20 on SP133191, Lot 10 on SP133192, Lot 390 on SP133193, Lot 1 on RP35158, Lots 2&3 on RP46302, Lot 2 on RP46303, Lot 1 on

RP46806, Lot 2 on RP896513 owned by Pacific Exchange Holdings Pty Ltd.

- Lot 1 on RP97710 owned by Michelle King & Darwin King.

This report describes:

- A hydrologic analysis of the Woolaman Creek catchment (including Undullah Creek) and of the catchment of an unnamed tributary traversing the eastern end of the site.
- A hydraulic assessment of Woollaman Creek and Undullah Creek and a separate assessment of the unnamed eastern tributary.

This report has been prepared to support the Master Planning process for the proposed Flinders Grove development and as such is conceptual in its nature. Future refinements and more detailed analysis will be required to support detailed design of each stage of the development.

This work considers and is based upon LIDAR survey data (supplied by Mortons Urban Solutions) together with regional topographic maps.

2 Site description and proposal

2.1 Location

The Flinders Grove site is situated at Undullah, approximately 18 kilometres north-west of Beaudesert and 10 kilometres west of Jimboomba in south-east Queensland. The site comprises twenty-two (22) properties with a total site area of approximately 3,919 hectares.

The site is traversed by Undullah Creek, running north-south, and Woollaman Creek, running west-east along the southern edge of the site. The site is accessible from the east by Mt. Lindesay Highway and Undullah Road.

2.2 Catchment description

The site lies within the lowland freshwater catchment of the Logan River. Two major creeks drain the Western portion of the site. Undullah Creek drains a 2,949ha catchment immediately to the north of the site, then runs north to south through the site and joins Woollaman Creek at its southern end.

Woollaman Creek drains a more substantial catchment to the west of the site (6,315ha upstream of the junction with Undullah Creek) and then runs west to east along the southern site boundary before joining Teviot Brook, approximately 1.4km downstream of the site.

The total catchment area contributing runoff to the two creeks upstream of the downstream site boundary is 10,243ha.

The smaller eastern portion of the site drains to the southeast via an unnamed tributary to its junction with Teviot Brook approximately 1.3km downstream of the site boundary and also downstream of the junction between Woollaman Creek and Teviot Brook. Teviot Brook flows under a railway bridge approximately 0.5km further downstream, this bridge acts as a hydraulic control on flows and water levels within Teviot

Brook to its upstream side.

Teviot Brook drains a large catchment, which includes the Wyaralong Dam (currently under construction). Teviot Brook ultimately discharges into the Logan River some 5km east of the site.

For the purpose of this preliminary investigation, Teviot Brook has been excluded from the modelling, with the two site catchments being modelled independently. Sensitivity testing has been undertaken based on a rating curve for the railway crossing to determine the impact of Teviot Brook on the downstream boundary conditions for the two parts of the model.

The major flowpaths and catchments are shown on Drawing No. 10511.1.2.

2.3 Existing development

Drawing No. 10511.1.2 shows that approximately 40% of site is primarily occupied by low grasses and shrubs in previously cleared areas. Some sand mining activities are located in the south-eastern corner of the site, adjacent to Woollaman Creek. A number of farm dams have been constructed on minor tributaries across the site. There are also some buildings scattered across the cleared portion of the site. The remainder of the site is occupied by dense vegetation.

Trees and short underlying grasses generally dominate vegetation across the steeply inclined slopes and ridges. Much of the lower storey vegetation has been partially disturbed by livestock in these areas.

Significant tree clearing has occurred across the lower and more gently inclined areas of the site for the purpose of livestock grazing. Subsequently these areas are now dominated by short grasses and contain only a sparse coverage of trees.

2.4 Proposed development

The Master Plan for the proposed future mixed-use development across the site is provided in Drawing No. 3605-ALL-P840, prepared by Mortons Urban Solutions.

3 Hydrologic assessment method

A hydrologic assessment was undertaken to estimate peak flows within the natural drainage network across the site under a range of rainfall events and to generate inflow hydrographs for input into a hydraulic model of the drainage network. This assessment was carried out using the Watershed Bounded Network Model (WBNM) computer modelling software, with verification of the generated flows against the Rational Method.

3.1 Rational Method

The Rational Method (Section 4.03 QUDM¹) is flexible in its data requirements and is able to produce satisfactory estimates of peak discharges from rural catchments up to 25km² in size, with the following data input:

- local intensity – frequency – duration data
- catchment areas
- runoff coefficients.

Discharge using the Rational Method is calculated by:

$$Q = \frac{F_Y C_{10} I A}{360}$$

where: Q = Peak flow (m³/s)

F_Y = Frequency factor

C_{10} = Runoff coefficient (10yr)

I = Rainfall intensity (mm/hr)

A = Catchment area (ha)

Peak discharges were estimated for the pre-developed (existing) site for events with average recurrence intervals (ARI) of between 1 and 100 years.

The overall catchment is significantly larger than the 25km² upper area limit recommended for application of the Rational Method). Accordingly, a Rational Method analysis was conducted only for the smaller (eastern) catchment, for verification of the WBNM model results.

It is considered that the WBNM model parameters (lag Parameter (C) value and defined loss rates) selected for the eastern catchment will be appropriate for application across the entire site and external catchment, due to the close proximity and similarity in the physical characteristics of the catchments.

3.1.1 Time of concentration

The time of concentration (t_c) for the eastern catchment upstream of the site discharge was estimated using the Modified Friend's Equation for rural catchments up to 25km² in accordance with the recommendations contained in QUDM. Details of the assumptions for these calculations are shown herein.

Modified Friend's Equation

$$t_c = 800L / (Ch.A^{0.1}.S_e^{0.2})$$

where: t_c = Time of concentration (min)

L = Length of flowpath from catchment divide to outlet (km)

Ch = Chezy's coefficient at the site = $R^{1/6}/n$

R = Hydraulic radius = $0.65R_s$ where stream slope varies appreciably along the stream

R_s = Hydraulic radius at the initially assumed flood level at the site

n = Average Manning roughness coefficient for the entire stream length

A = Catchment area (ha)

S_e = Equal area slope of stream flow path (%)

In order to estimate the hydraulic radius, an initial flood level for the downstream eastern catchment boundary was approximated by comparing the Q100 flood inundation extent for the Greater Flagstone Planning Area to the contours derived from the LIDAR survey data as shown on Drawing No. 10511.1.3. This resulted in an initial estimate

¹ Queensland Department of Natural Resources & Water, 2007, *Queensland Urban Drainage Manual*, Edn 2, Department of Natural Resources & Water, Brisbane.

² Note, attempts have been made by Gilbert & Sutherland to obtain the Logan City Council TUFLOW model to further calibrate modelling results. After discussions with LCC Officers, it appears that the model is currently (at the time of publishing this report) in its final stages of development. Future 10511 FLD AJF1F.DOCX / FLINDERS GROVE / PIDC – CONCEPTUAL FLOOD ASSESSMENT

of the 100 year ARI flood level at approximately 35m Australian Height Datum (AHD).

The channel cross section was extracted at this location to determine the wetted perimeter and cross sectional area of the channel below 35m AHD and thus estimate the hydraulic radius, R_s .

The time of concentration for the eastern catchment is shown in Table 3.1.1.

Table 3.1.1 Pre-development time of concentration by Modified Friend's Equation

Parameter	Value
L	6.892 km
R_s	5.90
R	3.84
Ch	15.6
n	0.08
A	932.6 ha
S_e	1.2 %
t_c	165 minutes

3.1.2 Rainfall intensity-frequency-duration data

The rainfall intensities for the simulation of design rainfall events were derived for the site using the Bureau of Meteorology IFD tool and AUSIFD2.0 in accordance with the recommendations contained in AR&R. The standard AR&R temporal patterns were used in the modelling.

3.1.3 Runoff coefficients

The runoff coefficient for the 10 year (C_{10}) average recurrence interval (ARI) was adopted based on recommendations in QUDM, Table 4.05.3(b). The value of 0.70 for medium density bush with low soil permeability was adopted for the site in its present state.

3.2 WBNM modelling

The Watershed Bounded Network Model (WBNM) is an event-based hydrologic model that calculates flood hydrographs from storm rainfall hyetographs. It can be used for modelling natural,

partially developed and fully developed catchments.

For developed catchments, it calculates runoff from pervious and impervious surfaces and routes it through the major system of open watercourses.

WBNM does not model the details of piped drainage systems. It can be used to generate hydrographs from an actual storm event and or a design storm utilising Intensity – Frequency – Duration (IFD) data together with dimensionless storm temporal patterns.

The WBNM model is flexible in its data requirements and is able to produce satisfactory results with the following data input:

- local intensity frequency duration data
- design temporal patterns
- subcatchment areas
- impervious areas.

The modelled flows were verified against the Rational Method flows for the eastern catchment. Further calibration of the modelled flows across the entire site will be carried out once data from Council's Teviot Brook flood study (currently under development) becomes available.

3.2.1 Storm data

The rainfall intensities for the simulation of the design rainfall events were calculated in accordance with the procedure outlined in Book 2 of Australian Rainfall and Runoff 1998 (AR&R) in combination with the Bureau of Meteorology's online IFD tool to determine the local design rainfall parameters, and AusIFD2.0 to generate an IFD table for the required storm durations. The temporal patterns used were also adopted from AR&R (1998).

Losses used in the modelling were estimated in order to replicate the flows calculated using the Rational Method.

Losses were determined in conjunction with the recommendations contained in the XP-RAFTS reference manual and those published in Australian Rainfall and Runoff 1998, Book 2, Design Rainfall Considerations, Section 3.4. The

losses adopted for this catchment are shown in Table 3.2.1.

Table 3.2.1 Model losses

Storm ARI (years)	Pervious Initial loss (mm)	Pervious Continuing loss (mm)	Impervious Initial loss (mm)
1	15	1.5	0.5
2	15	1.5	0.5
5	12	1.5	0.5
10	10	1.5	0.5
20	5	1.5	0.5
50	2.5	1.5	0.5
100	0	1.5	0.5

3.3 Peak flow site characteristics

The physical characteristics of the catchment were described in Section 2 of this report. In its

current state (pre-development scenario), the site may be described as rural and an impervious fraction of zero has been adopted. This assumption is considered to be conservative as a few small buildings are currently scattered across the site.

Although there are a number of small dams within the site, these have not been included in the modelling. That is, it has been assumed that these dams may be full at the commencement of a critical storm event. Again, this is considered to be a conservative approach.

For the purpose of modelling, the three major catchments, Undullah Creek (U), Woollaman Creek (W), and the eastern catchment (E), have been divided into a number of sub-catchments, as shown on Drawing No. 10511.1.4.

4 Hydrologic assessment results

4.1 Rational Method peak flows

The assumptions adopted to determine the peak flow rates discharging from the site in its present state are listed below:

- Runoff coefficient C_{10} 0.70
- Time of concentration t_c 165min
- Catchment area A 932.6ha

The resultant peak flow rates over the standard ARI events are shown Table 4.1.1.

Table 4.1.1 Peak flows by Rational Method

ARI (yrs)	$C_Y = F_Y \cdot C_{10}$	I (mm/hr)	Q (m ³ /s)
1	0.560	16.6	24.1
2	0.595	21.4	33.0
5	0.665	27.1	46.7
10	0.700	30.6	55.5
20	0.735	35.3	67.2
50	0.805	41.7	87.0
100	0.840	46.6	101.4

4.2 WBNM modelling results

The sub-catchments and WBNM model layout for the site are shown on Drawing No.10511.1.4.

4.2.1 Existing Case

The inputs and assumptions detailed above were incorporated into the WBNM model to generate hydrographs for the subject site. Peak catchment discharges were estimated for storms with durations ranging from 5 minutes to 72 hours for each standard ARI.

A lag parameter (C) value of 1.60 was adopted based on the recommended value in the WBNM documentation. A stream lag factor of 1.0 was used for routing along all flowpaths representing flow through a natural channel.

The peak flows of the generated hydrographs at the downstream boundary of the eastern catchment under a range of rainfall events are shown in Table 4.2.1 for verification against the Rational Method flows.

Table 4.2.1 WBNM modelled and Rational Method peak flow comparison for eastern catchment

ARI (years)	Rational Method calculated flow (m ³ /s)	WBNM modelled flow (m ³ /s)
1	24.1	20.7
2	33.0	32.1
5	46.7	50.8
10	55.5	62.8
20	67.2	82.4
50	87.0	105.0
100	101.4	122.4

Based on the results in Table 4.2.1, and taking into account the limitations of the Rational Method being applied to large catchments, it is considered that the modelling results are satisfactory.

Adopting the same modelling parameters (lag parameter (C) and model losses) for the larger Woollaman Creek catchment (including Undullah Creek), the peak flows of the generated hydrographs at the site boundary on Woollaman Creek are provided in Table 4.2.2.

Table 4.2.2 WBNM modelled peak flows from the Woollaman Creek catchment

ARI (years)	WBNM modelled flow (m ³ /s)
1	137
2	213
5	329
10	407
20	535
50	675
100	794

4.2.2 Developed Case

The WBNM model was then modified to include the proposed development as described in Drawing No. 3605-ALL-P840, prepared by Mortons Urban Solutions.

For this preliminary assessment, it has been assumed that the catchment boundaries will remain unchanged and there will be no works carried out within the channels.

To represent the proposed development within the model, different impervious fractions have been adopted for each proposed land use type. The adopted impervious fractions are outlined in Table 4.2.3.

Table 4.2.3 Impervious fractions adopted for each proposed land-use type

Land use type	Impervious fraction
Park Living	20%
Outer Suburban	70%
Suburban	75%
Inner Suburban/Village	80%
Town Centre	90%
Industrial	90%

The areas of each landuse type applied to each of the modelled sub-catchments are shown in Drawing No. 10511.1.5.

The estimated peak flows discharging from each major catchment, under developed conditions are provided in Table 4.2.4:

Table 4.2.4 WBNM modelled developed peak flows at site discharge points

ARI (yrs)	Woollaman Creek catchment (m ³ /s)	Eastern catchment (m ³ /s)
1	136	33.0
2	211	47.8
5	321	69.6
10	391	83.6
20	516	106.7
50	652	131.9
100	768	153.7

The results in Table 4.2.4 demonstrate that the proposed development in the eastern catchment leads to an increase in peak site discharge, which will require flow mitigation measures to be adopted.

For the larger Woollaman Creek catchment, the proposed development leads to a slight reduction in the peak site discharge, due to changes in the timing of the discharge hydrographs. This is analysed in more detail through the hydraulic analysis described in Section 5 of this report.

5 Hydraulic assessment

5.1 Overview

A hydraulic assessment was undertaken to establish existing flood levels across the site under a range of design flood events and to identify flooding constraints on proposed sand mining activities and planning for future mixed-use development across the site.

For the purpose of hydraulic assessment, two separate models have been setup to investigate flows upstream of the two site discharge points, from the Woollaman Creek catchment and the eastern catchment.

Both catchments drain to Teviot Brook, however Teviot Brook also caters for a much larger external catchment. At the time of modelling there was insufficient detail of the external catchment available to enable modelling on the same scale as the site and thus form a single combined model of the system.

We note that the Urban Land Development Authority (ULDA) has commissioned a flood study of the Teviot Brook catchment, including the subject site, however details of this study were not available at the time the modelling was undertaken. Accordingly, the modelling described herein will be verified against the ULDA study when it becomes available, as part of the detailed planning for future development of the site.

There are no hydraulic structures impeding flow upstream of or within the site, however any proposed works must ensure that peak flood levels and flows at the site's boundaries (upstream and downstream) are not adversely impacted.

5.2 Approach

To analyse existing flood levels across the site, a SOBEK model, which is a detailed fully dynamic 1D/2D modeling package, developed by Deltares (formerly the Delft Hydraulics Institute), was formulated. The model was setup for current (undeveloped) conditions, then modified to represent proposed developed conditions as described in the Concept Plan for the Flinders

Grove development. The model set-up and methodology is described in the following sections.

5.2.1 Establish a Base Case model

Cross sectional profiles along the major flowpaths within the site were created using Aerial LIDAR survey data for the site, supplied by Mortons Urban Solutions.

For the eastern catchment, a two-dimensional grid was also extracted from the LIDAR data for the downstream portion of the model where flow is not constrained within a defined channel.

A Manning's 'n' roughness coefficient of 0.08 was adopted throughout the model, to represent the dense vegetation within the model extent.

The SOBEK model layout is shown on Drawing No. 10511.1.6.

5.2.2 Determine initial boundary conditions

Initially, a stage-discharge relationship was derived from the channel slope, roughness and cross-sectional profiles at the downstream limit of each model using a Manning's analysis. This was adopted as the model boundary condition for preliminary model runs.

The Base Case model was run for the critical 100 year ARI storm event and preliminary flood levels for the downstream portion of each model were extracted.

5.2.3 Verify boundary conditions

The impacts of regional water levels in Teviot Brook were examined to determine whether tailwater levels (rather than upstream flows) controlled water levels at the downstream boundary of each model.

For this preliminary flood assessment, a representative regional tailwater level was established by first determining an appropriate 100-year ARI discharge from the Teviot Brook catchment and then calculating the corresponding water level at the railway using a Manning's analysis.

A review of the Wyaralong Dam Environmental Impact Assessment indicates a 100-year ARI discharge of 1,164m³/s in Teviot Brook at the

approximate location of the railway crossing under pre-dam conditions, and 878m³/s at the same location under post-dam conditions. At the time of this analysis, the dam was under construction, therefore post-dam conditions may be assumed to be appropriate for this study.

Teviot Brook discharges into the Logan River approximately 1,700m downstream from the railway crossing. However there is limited detail available on the exact location at which the estimated flow in Teviot Brook has been derived. Given the potential differences between the two hydrologic models adopted, it was decided to adopt a conservative estimate of 1000m³/s for the the 100-year ARI flow at the railway.² An analysis of the crossing capacity, based on the preliminary channel slope, roughness and cross-section indicates the 100-year ARI flow of 1000m³/s corresponds to a flood level of 32.055m AHD.

Both models were then re-run with a fixed tailwater level of 32.055m AHD, and the resultant flood levels compared to those generated using flow-controlled boundary conditions. It was determined that the critical boundary condition for the Woollaman catchment was the initial stage-discharge relationship, whilst the regional tailwater governed flood levels in the eastern catchment.

5.2.4 Hydraulic simulation

To estimate existing flood levels throughout the site, the Base Case model was run for a range of design storm events based on WBNM flow hydrographs for the ARI 5, 20, 50 and 100 year events. The resultant flood inundation levels for the site in its present state are shown in Drawing No. 10511.1.7, with levels at each modelled cross-section and detailed drawings of results within each model reach included in Appendix 2.

5.2.5 Create a Developed Case model

The model was then re-run using the Developed Case inflow hydrographs generated from the WBNM model for the same design storm events

as for the Base Case. The resultant flood inundation levels for the developed case model are tabulated in Appendix 2, for comparison with the Base Case results.

Drawing No. 10511.1.8 shows a summary of the flood impacts resulting from the proposed development. As noted in Section 4.2.2, in the eastern catchment the proposed development results in an increase in peak site discharge and a corresponding increase in peak flood levels is observed. As such, on-site mitigation measures will be required to attenuate flows back to existing levels within this catchment. Design of these measures will be undertaken at a precinct planning stage.

For the Woollaman Creek catchment (including Undullah Creek), the reduction in peak flows noted in the hydrological modelling corresponds with a slight reduction in the flood inundation levels within Woollaman Creek. Flood levels in some of the upper tributaries of Undullah Creek are increased, however these impacts are contained within the site and therefore can be managed as part of the proposed development. The model results indicate no increase in peak flows or flood levels external to the site.

An analysis of the flow hydrographs across the site indicates that the reduction in flow is due to separation of the peak discharge from various regions within the catchment. The location of the proposed development, being at the lower end of and occupying only a small fraction of the larger catchment, means that the developed flows from the portion of the site being developed will drain to the site discharge point faster and before the peak flow from the upstream catchment reaches the development.

It is therefore recommended that no on-site detention be provided within this catchment. This is because attenuating the local developed flows would only serve to delay the peak discharge from the development, which gives rise to a risk that it will coincide with the upstream peak discharge and potentially increase existing flood inundation levels.

² Note, attempts have been made by Gilbert & Sutherland to obtain the Logan City Council TUFLOW model to further calibrate modelling results. After discussions with LCC Officers, it appears that the model is currently (at the time of publishing this report) in its final stages of development. Future modelling for the site will endeavour to take the results of Council's model into account.

6 Conclusion

A hydrologic and hydraulic analysis has been carried out to estimate existing flood levels in the major flowpaths across the Flinders Grove site. Existing flood inundation levels have been defined and are presented on Drawing No. 10511.1.7. These defined flood levels can be used as a basis for determining constraints for planning of future multi-use development of the site.

A preliminary analysis of the hydraulic impact of the proposed development has been undertaken. The results of this analysis indicate that the proposed development within the eastern catchment leads to an increase in peak site discharge and flood levels and thus flow-attenuation measures will be needed to ensure no adverse impacts external to the site. These measures would be designed at a precinct planning stage.

For the western, Woollaman Creek, catchment (including Undullah Creek), the proposed development results in a slight reduction in peak water surface levels and flows in the lower portion of Undullah Creek and within Woollaman Creek. Flood levels in some of the upper tributaries of Undullah Creek are increased, however these impacts are contained within the site and therefore can be managed as part of the proposed development. The model results indicate no increase in peak flows or flood levels external to the site.

It is recommended that on-site detention not be provided within the Woollaman Creek catchment. This is because attenuating the local developed flows would serve to delay the peak discharge from the development, which may result in these flows coinciding with the upstream peak discharge and thus increasing the existing flood inundation levels.

7 Appendix 1 – Reference drawings

FLINDERS
GROVE

Lot 79 on S312955, Lot 80 on SL 1163
 Lot 2 on RP 896513, Lot 74 on S312820
 Lot 42 on SL 5873, Lot 32 on S311402
 Lot 19 on S311970, Lot 390 on SP 133195
 Lot 2 on RP 46302, Lot 1 on RP 46806
 Lot 2 on S 31878, Lot 200 on SP 133189
 Lot 1 on RP35758, Lot 2 on RP 46303
 Lot 3 on S 311896
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