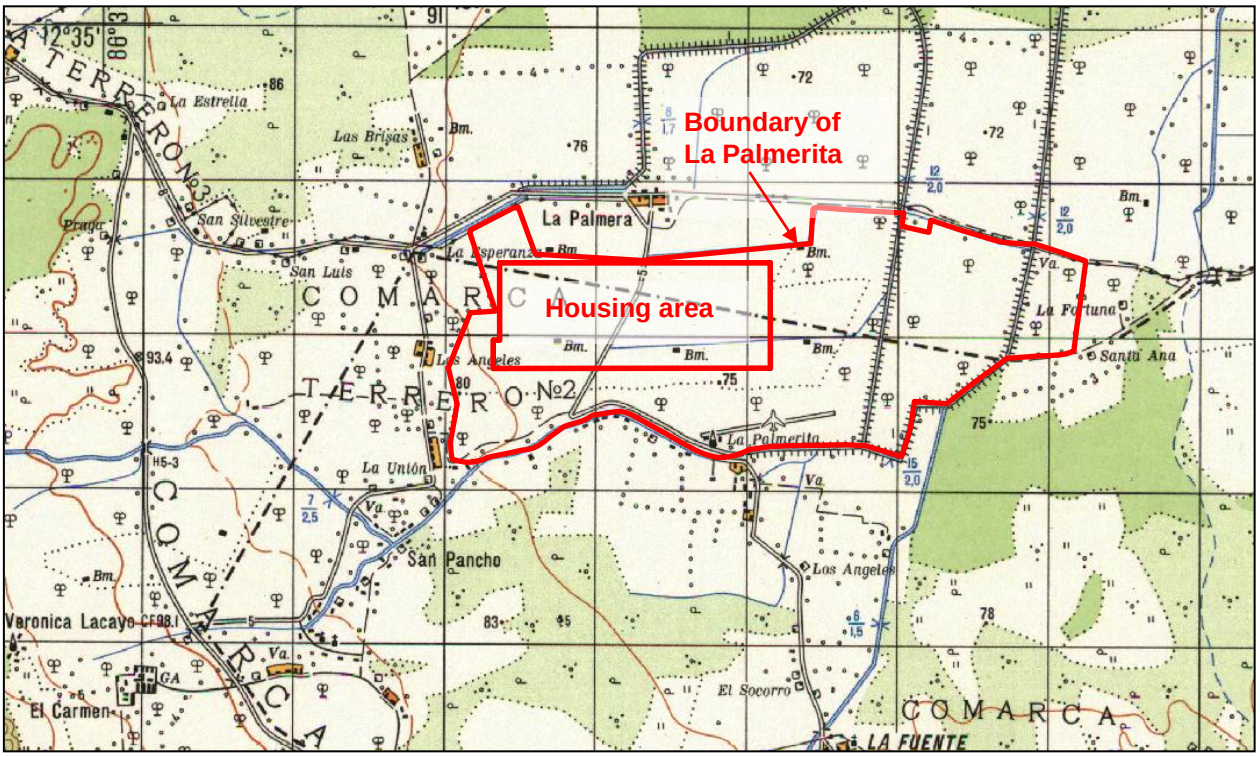
DRAINAGE STUDY

Proposal

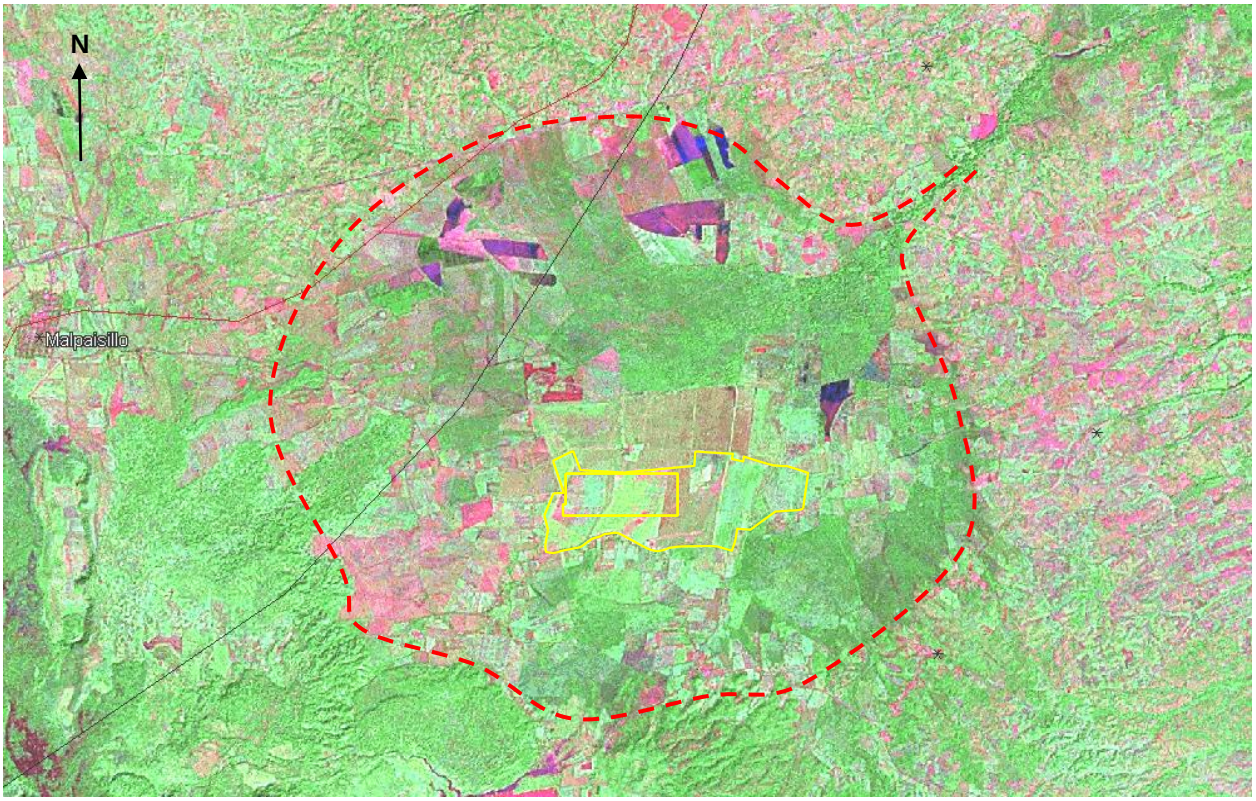
The proposed development occupies an area of approximately 173 Mz at La Palmerita, a former cotton plantation in relatively flat lying land in Comarca El Terrero No.2, Malpailsillo. The proposal is for 153 houses each with an approximate area of 36 m^2 to be constructed in lots of 1 Mz each on a grid system with a minimum spacing of 42 metres between each house. Apart from some buildings and other amenities in the communal areas, the only impermeable surfaces to be constructed will be the houses themselves and associated latrines, accounting for approximately 0.5% of the total area of the development. La Palmerita should not therefore be considered as an urban development in planning terms, but rather as a dispersed rural community. Changes to land use as a result of the proposed development are thus minimal and the vast majority of the land will continue to be used for agricultural production.



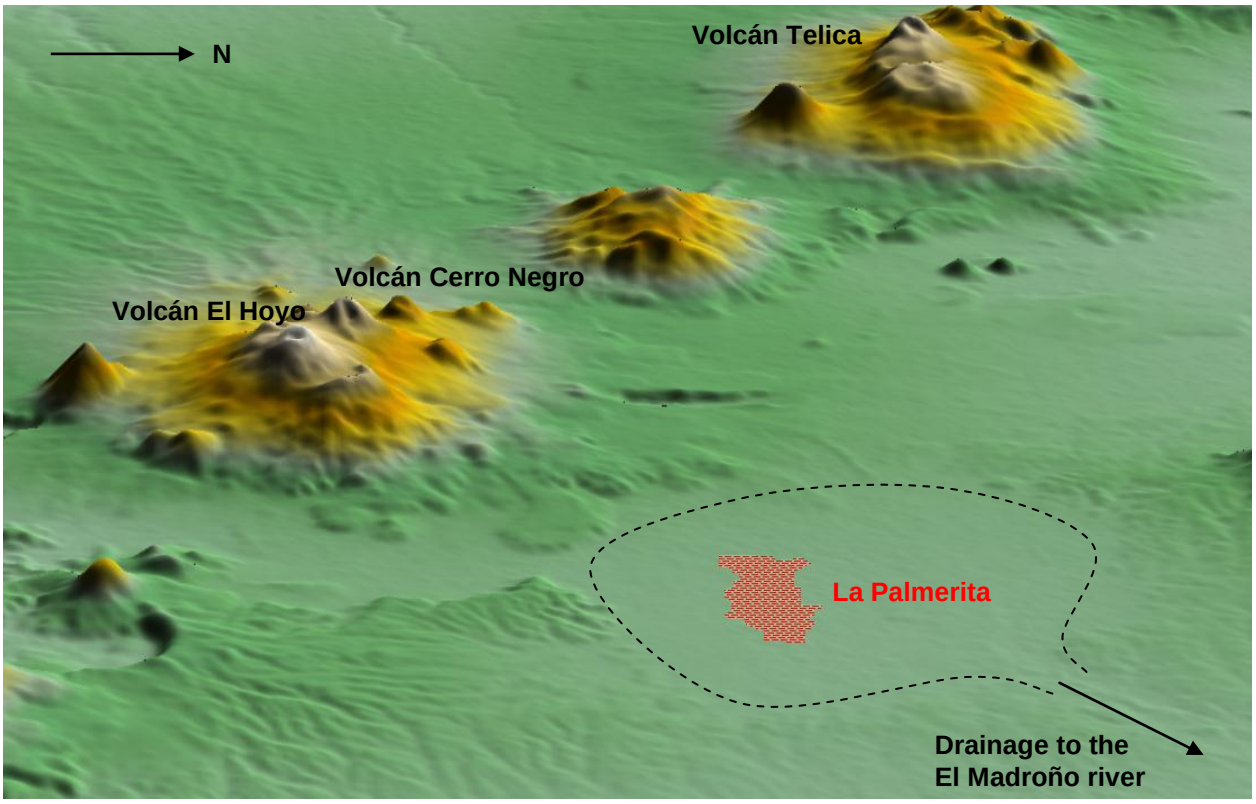
Topography and geological setting

The site is situated in the centre of a geological feature known as the Malpaisillo caldera. This caldera has a diameter of approximately 9 km and was formed by the collapse and subsequent infilling of an ancient volcanic complex. Although the caldera has now effectively been filled completely with sediment from the surrounding area, the natural drainage pattern is the direct result of the geological origin of the area. Water from the surrounding area drains into the flat-lying filled caldera from which it subsequently drains to the north-east as part of the El Madroño micro-catchment.

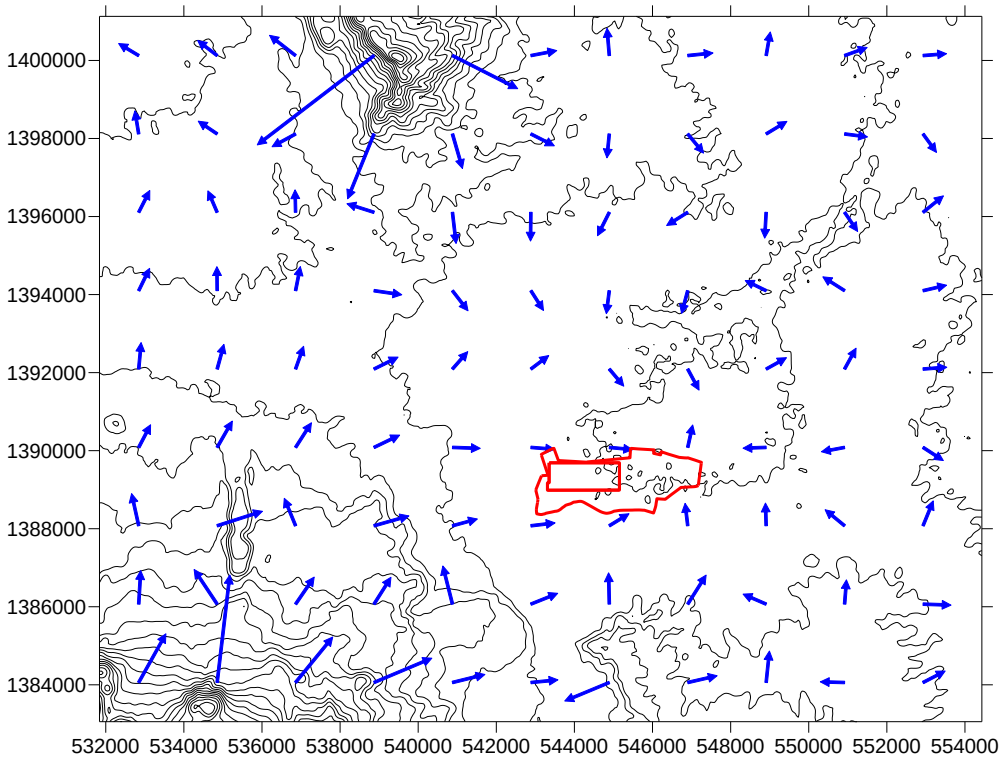
The Malpaisillo caldera can be observed clearly from satellite imagery. On the image below the limits of the caldera are shown as a red dotted line with the limits of La Palmerita and the proposed housing area shown in yellow.



In order to model more accurately the drainage of this area, digital elevation data were obtained from the SRTM90 dataset which features a node spacing of 90 metres. A three-dimensional digital terrain model image was constructed from this dataset using SURFER and is presented below. This image looking towards the west shows the location of La Palmerita within a circular area of flat ground which is the Malpaisillo caldera. The drainage pattern from the Maribios volcanoes in the south and south-west is towards the caldera, with drainage from the caldera in the north-east, in the bottom right hand corner of the picture.



A more conventional plot of contours and vectors (length of arrows is proportional to gradient) is shown below for the area of the Malpaisillo caldera itself showing a general pattern of drainage towards the north and east.



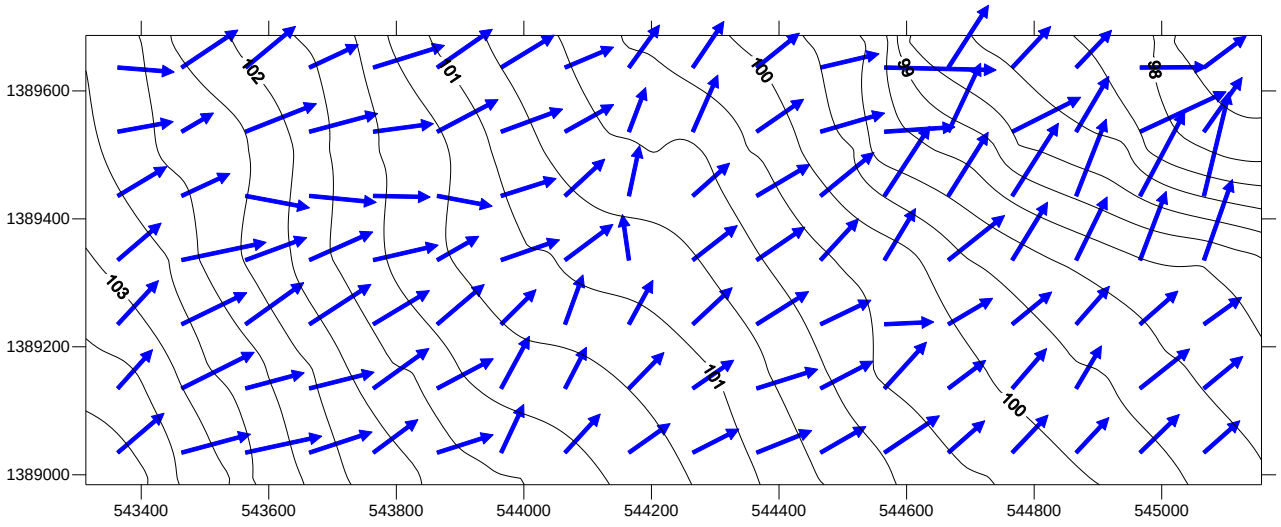
Flood risk assessment

A risk assessment, previously undertaken for an earlier housing project by INETER, has been separately submitted to INVUR. This study concluded that the whole of the area of investigation was suitable for the construction of houses. It was recommended that an adequate system of drainage be constructed for the 'housing complex' to reduce the risk of flooding. It was considered that storm waters should be drained towards the north-east and under no circumstances should drainage be constructed in the direction of the access roads (to the south and west).

It should be noted that the project previously proposed (for which this risk assessment was undertaken) was for a much more concentrated 'urbanisation' in the south western corner of the site. It is clear that more concentrated housing developments are likely to generate more storm water runoff and consequently require more developed drainage systems.

Topographic survey

A topographic survey of the proposed housing area was undertaken by Nuevas Esperanzas, recording elevation for the corners of each of the 153 lots. This data is presented separately but is presented here in the form of a contour plot (0.25 metre spacing) with vectors (length of arrows is proportional to gradient):



This plot shows a clear drainage pattern towards the north-east with a very consistent slope, both in terms of direction and gradient. The average slope of proposed area of housing is 1:324.

In addition to the topographical survey, a walk-over survey was undertaken of the drainage ditches and bunds which cross the site, taking into account the first hand observations of a resident who has lived next to the site for over 50 years, working on the finca itself for much of

that time when it was cultivated for cotton. The conclusion of this survey was that the only area susceptible to flooding is along the southern boundary of La Palmerita close to existing bunds which have occasionally been breached due to poor maintenance and erosion by animals. This was close to the area previously proposed for housing, to which the INETER risk assessment specifically relates. The present proposal is to build houses further north, away from this more vulnerable area. The area of the present proposal has not been flooded in the last 50 years according to the eyewitness account including, most notably, during Hurricane Mitch.

Drainage design

There are essentially two options for drainage of the area at La Palmerita where the houses are to be constructed. The first option is to allow the area to drain naturally according to the gradients shown in the figure above and the second option is to channel storm waters east and north along the roads to be established at the site to the north-eastern corner of the housing area. From this point the water would need to be channelled to a suitable drainage channel or river system, the closest of which is a drainage channel flowing towards the east in the neighbouring property of La Palmera.

Based on a simple calculation using the empirical Rational Formula ($Q = 1/360 \times C \times I \times A$ where Q is the maximum flow in m^3/s, C is the coefficient of runoff, I is the design intensity in mm/hr and A is the drainage area of the catchment in m^2), a design flow at the north-eastern corner would be at least 2.5 m^3/s (using intensity-duration-frequency curves for León for an event with a 5 year return period). This quantity of storm water would require a significant channel to be constructed draining the area to the north. Furthermore, significant earth movement would be required to construct roads with sufficient capacity along the north and eastern edges of the site to carry flows of around 1 m^3/s. This option may be necessary if the proposed housing development were to be in the form of a concentrated 'urbanisation', but in the context of a dispersed rural community living on permeable soil, this should not be considered appropriate or desirable.

In the last 10 years, traditional thinking on storm water drainage has been overturned and new international standards are emerging for more sustainable solutions. Previously, it was considered necessary to drain built areas of storm water as rapidly as possible using a system of engineered drains. However, this has led to major problems of flooding in lower parts of river catchments as well as increased erosion and contamination of watercourses with runoff from road surfaces. Much has been published on so-called Sustainable Urban Drainage Systems (SUDS) and it is now considered more environmentally sustainable to retain storm water for as long as possible near to the point where the rain falls and to make use of natural features to retain, drain and treat storm water runoff. Attached is a recent paper on the various technologies currently being applied.

Furthermore, for dispersed rural communities such as La Palmerita, engineered systems of drainage are uncommon and not usually necessary. A comparison can be made with a rural housing project at El Tanque near Posoltega where a similar number of houses to the current proposal were constructed for victims of Hurricane Mitch. The project has very similar

characteristics: a flat terrain with a constant gradient of approximately 1:300, permeable and semi-permeable soil and houses of 36 m^2 in lots of 1 Mz each. This community was built with no engineered system of drainage and no works have ever been required to prevent flooding apart from a small amount of earth movement to infill a depression on one of the roads.

Taking into account the problems with engineered systems of drainage, the current 'Best Practice' for drainage design and the experience of similar development projects, it is proposed that storm water drainage is based on the natural gradients present which will drain storm water from the site along the length of the northern and eastern boundaries. This is considered preferable to an engineered system of drainage in which flows are concentrated into channels, increasing the intensity of runoff from the site.

Mitigation measures

Any development involving the construction of buildings in land previously used for agriculture will inevitably generate increased runoff from impermeable surfaces such as roofs and concrete patios. In the case of this development, the area of impermeable surface will be around 0.5% of the total area designated for housing. The lots of 1 Mz each will be used primarily for agricultural production with only a very small proportion of the area occupied by houses, latrines, patios or other such 'hard surfaces'. In view of the negligible change in the overall runoff characteristics of the land, no specific mitigation measures are considered necessary. There are, however, opportunities presented by the present project to encourage sustainable management of rain water and Nuevas Esperanzas has been active in several communities promoting concepts such as rainwater harvesting, soil and water conservation and micro-catchment management. Below is a photograph of a rainwater harvesting system at San Jacinto.

Nuevas Esperanzas will ensure that these concepts are also promoted at La Palmerita, although in this case it would not be necessary to construct large storage tanks like those at San Jacinto as La Palmerita has adequate alternative water sources for domestic use. It may be possible to introduce simpler systems of rainwater harvesting from roofs which provide useful supplementary water sources for irrigation of family gardens, for example, as well as retain water from storm events, thereby mitigating the increase in runoff due to the construction of houses. Management of storm waters is equally important in the agricultural areas behind each house and systems of soil and water conservation will be promoted. These environmentally sustainable solutions form an integral part of the work which Nuevas Esperanzas undertakes in its development projects.

Management of grey water from washing will be by means of soakaways. The design of the water and sanitation system includes the construction of a soakaway behind the tap stand proposed for each lot. This soakaway can also be used to receive grey water from washing. Alternatively, informal systems of drainage of grey waters can be constructed such as those already in use at La Palmerita. Below are some photos from La Palmerita showing improvised systems of drainage using hand-dug channels and soakaways. In the context of a dispersed rural community, this should be considered the most environmentally sustainable and appropriate solution.

Conclusions

It is recognised that the proposed housing development at La Palmerita is situated in a relatively flat-lying area in the centre of the Malpaisillo caldera, a geological feature which receives flows of runoff from surrounding hilly areas. The site itself has a consistent gradient of approximately 1:300 towards the north-east. The soil is permeable and in view of the dispersed nature of the rural housing development, it is proposed that the natural gradient of the site is utilised to drain water from the northern and eastern boundaries of the site. No engineering works are considered necessary or appropriate as these tend to concentrate runoff and create more problems downstream. However, although not necessary in view of the minimal impact the houses will have on runoff, a range of conservation techniques for the sustainable management of storm water will be promoted.

Report prepared by:

Andrew Longley PhD, MSc, MA, FGS
Programme Director, Nuevas Esperanzas & Consultant Hydrogeologist