Appendix L –

Land Use Development Propensity Forecasting Technical Memo

Environmental Statement

East-West Arterial Extension:

Section 2 (Woodland Drive – Lookout Road)

Section 3 (Lookout Road – Frank Sound Road)

Date: December 13, 2024

To: The National Roads Authority (NRA)

From: Whitman, Requardt & Associates, LLP

Subject: Land Use Development Propensity Forecasting

CC: Environmental Assessment Board (EAB)

Contract Number: PPC-2022-NRA-007-RFP

WRA Work Order Number: 35184-000

Project: Phase 2 for the East-West Arterial Extension Environmental Impact Assessment

1 Introduction

A project specific development propensity prediction tool was prepared to generate estimates of how the change in accessibility due to the Proposed Project may impact the propensity for future land development at a parcel-level resolution for the study area. This future land development propensity can be useful for land use planners and decision makers to understand the potential for future land use changes that may occur with or without the Proposed Project. This memo is organized as follows:

- Data sources and variables considered within the study area are described.
- The developed methodological framework for land development forecasting is presented.
- The key findings from the analysis are reported.
- Conclusions are provided along with the limitations of the analysis and future studies considerations.

2 Limitations

Estimating induced development resulting from a proposed transportation project typically requires clear indications from property developers that the development will only occur if the Proposed Project is built. In the absence of this information detailed econometric models are required. These models need to account for complex location and supply variables such as the real estate market (property values, cost of development, access to jobs, access to goods and services, access to recreation and other quality of life factors, etc.) as well as demand variables (in-migration, out-migration, births, deaths, labour policies, tourism policies, etc.). This information is required in detail over a period of time, which reflects changes in both supply and demand (i.e., what changes in development patterns occurred due to prior transportation investments or changes in economic policy). Another key limitation in estimating future induced development is the lack of official demographic forecasts for Grand Cayman. This uncertainty is evidenced by the three future year population and employment scenarios being considered as part of the overall Environmental Statement (the scenarios are presented in **Chapter 15, Section 15.3.1**). These alternate futures represent three distinct possible futures in both the magnitude and location of population and employment growth as well as changes in cruise ship and freight assumptions. It is assumed that any of these three alternate futures may not be completely correct in 2074, but each of them would have substantial impacts on assumed demand for new homes, services, or jobs within the study area.

This overall lack of existing econometric models, detailed current and historic data, and lack of identification of committed developments that will only occur if the Proposed Project is constructed creates a high degree of uncertainty. However, evaluating development propensity can offer a framework for examining how the Proposed Project, and the access it would provide, might change the demand and pressure for future development on nearby land. In the absence of calibrated and validated existing econometric models or details on robust supply or demand variables needed to estimate, validate, or calibrate new econometric models for Grand Cayman as part of the Proposed Project evaluation, it was determined that a development propensity model would be created that accounts for known planned developments through future year 2046, area type variables, and access variables. Due to the lack of historic and detailed data required to estimate model structure and variables, a model was developed using an abridged Delphi Method whereby domain experts were consulted on the model structure and variables.

3 Data Sources and Variables

The study area for the propensity evaluation was defined as a 1.5-mile (2.4 km) buffer area surrounding the Proposed Project. Access to the Proposed Project will be limited to discrete intersection locations, which are described in **Chapter 6, Section 6.3.9**. For the selected study area, the Grand Cayman parcel GIS shapefile from the Lands & Survey Department was used to establish parcel boundaries. This data does not include any existing development indicators, and therefore, it was not possible to identify the developed parcels directly from the parcel data. An ArcGIS Imagery map was employed to determine the development status of each parcel to group the parcels into either developed or undeveloped categories. Each parcel was screened by defined criteria and then visually inspected in this classification approach (discussed in detail within **Section 4**). Current land use zoning information, provided by the Lands & Survey Department, was also considered. This data included 18 land use zoning classifications such as agricultural/residential, high/medium/low density residential, institutional, and neighborhood commercial. Using the spatial joining tool in ArcGIS, each parcel was tagged with an identified land use zoning classification. If any parcel was in two or more land use classifications, the most prominent one was assigned based on area. The next data taken into consideration was whether a parcel is located within a protected, national trust, or government area. To generate this information, the most recent Grand Cayman Island protected land, National Trust land and government land shapefiles were utilized. Another important factor considered is whether a parcel includes a planned future development or not (obtained from planned development geospatial data provided by the NRA).

The existing land use patterns surrounding each of the parcels were then examined. To incorporate existing land use patterns, a measure called "Area Score" was utilized, which is based on the current land use zoning incorporated into a grid resolution. The forecasting study area shown in **Figure 1** was overlaid with a 1-mile (1,609 m) by 1-mile (1,609 m) square grid configuration. In the analysis procedure, a 0.5-mile by 0.5-mile square grid configuration was also evaluated as a sensitivity test to determine how the size of the grids impacts the area score. The sensitivity test demonstrated that the size of the grid resulted in minor changes in propensity. The sensitivity test with the 0.5-mile grid size did not impact the locations of changes in development propensity due to the proposed project.

The grid configuration was then aggregated using the land use zoning area to generate shares of various zoning categories. The grid system along with the existing land use zoning classification are presented in **Figure 2**. The formulation used to generate each area score is provided as follows.

$$Area\ Score\ = \frac{\sum_{i=1}^{K} w_i * S_i}{\sum_{i=1}^{K} w_i}$$

Where, i indicates different planning zones, w_i indicates weight for zone i, S_i indicates the share of zone type i and K (=10) indicates number of planning zones considered in area scoring. The chosen weights for various zones are provided in the following **Table 1**. A weight represents the corresponding land use zone's importance in identifying an area (grid) as a potential developed area. This score was employed as a factor to estimate development propensity at the parcel resolution. Higher weights were given to areas with existing infrastructure represented by the presence of roads. Other higher-weighted factors included areas zoned for higher intensity such as hotel/tourism, beach resorts, or medium density residential as these zoning categories are typically assigned to locations more targeted for development from a planning perspective.

Table 1: Weights Considered for Estimating Area Score

Land Use Zone	Weight
Agricultural/Residential	0.5
Institutional	1.0
Low Density Residential	0.7
Medium Density Residential	1.5
Beach Resort/Residential	1.5
Hotel/Tourism	1.5
Neighborhood Commercial	1.0
Existing Private Roads	2.0
Undeveloped Approved Roadway Corridor	1.0
Private Canals	1.0

The next variable considered was the level of access to transportation facilities. To generate information about transportation accessibility, current roadway network data was collected for all roadway classes such as Primary Arterial, Secondary Arterial, Collector and access roads. The distance to the nearest roadway was estimated for each of the parcels within the study area. For the Proposed Project evaluation, the roadway access score was increased for parcels within a buffer of the Will T Connector plus parcels with intersection access to the Proposed Project for parcels that do not currently have roadway access. To incorporate the impact of the Proposed Project, the level of access (high access to no access) to the proposed intersections along the Proposed Project was included as a factor within the analysis. Buffer areas of 250 ft (76.2 m), 500 ft (152.4 m), and 1,000 ft (304.8 m) were defined around the proposed intersections based on the access (north/south/both directions) to be provided. In addition, access to the Will T Connector was also included for the Proposed Project scenario by considering the distance from the parcels. The parcels were divided into 4 groups using 3 distance buffers including 40 ft (12.19 m), 80 ft (24.38 m) and 120 ft (38.58 m) buffers. The exact impact of Will T Connector on development propensity has been presented in **Table 2**. The additional roadway access for the Proposed Project (Will T Connector and proposed intersection access) are presented in **Figure 1**. Distance to an undeveloped private right of way was also considered as a variable as parcels with access to undeveloped private right of way have higher potential to be developed in the future. The details of how these accessibility measures were incorporated into land development prediction are provided in the following section.

Figure 1: Additional Access for the Proposed Project

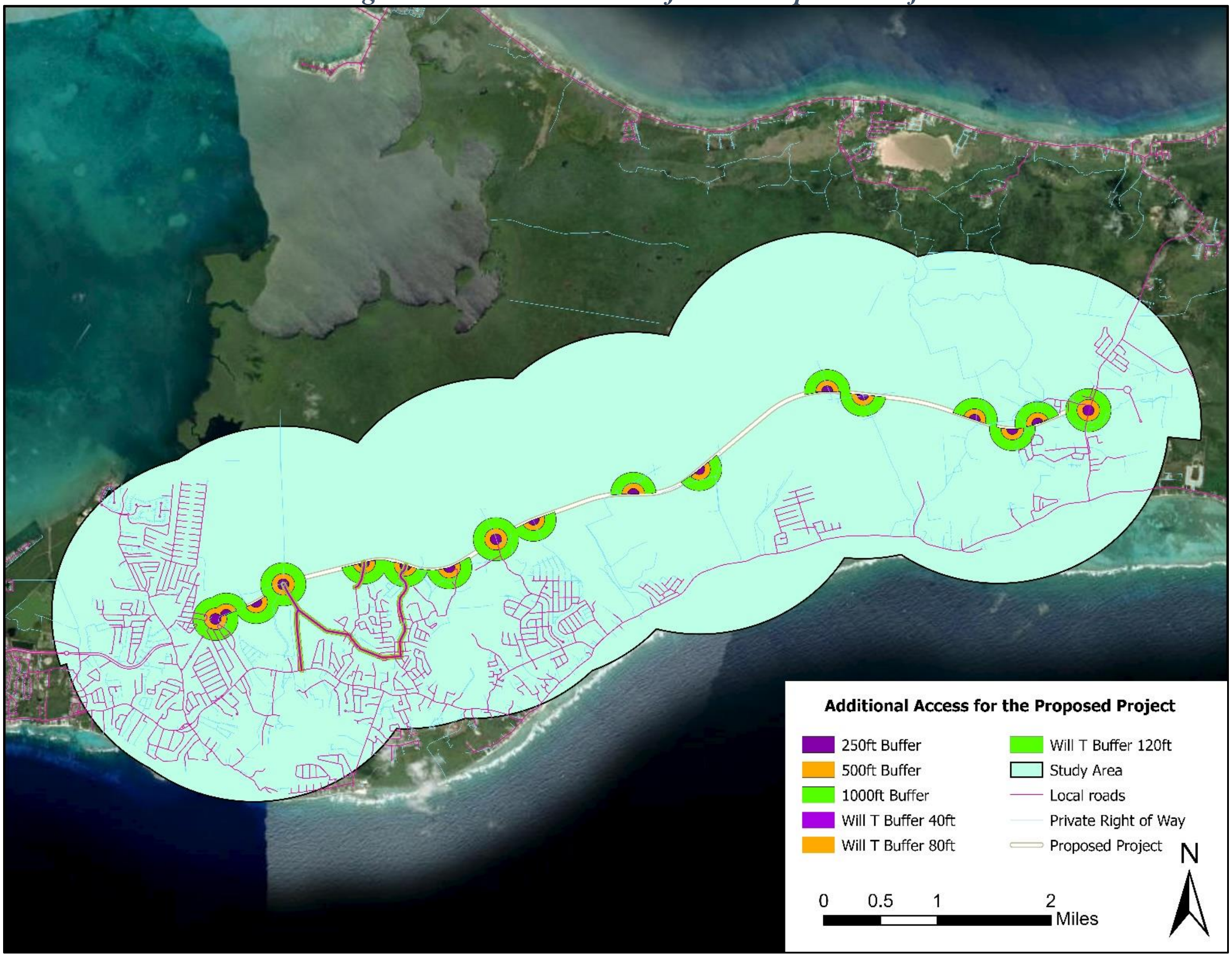
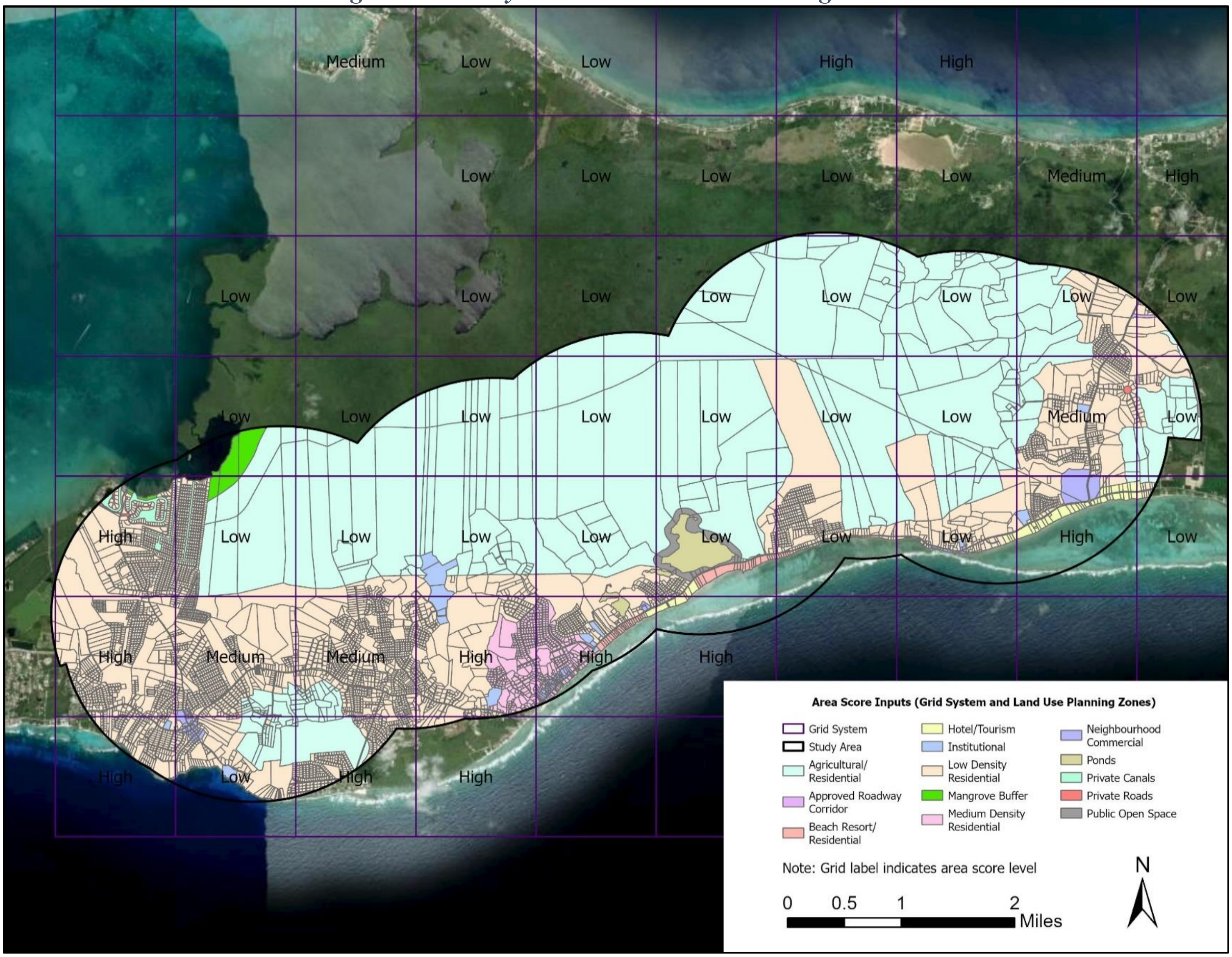


Figure 2: Grid System and Land Use Planning Zones

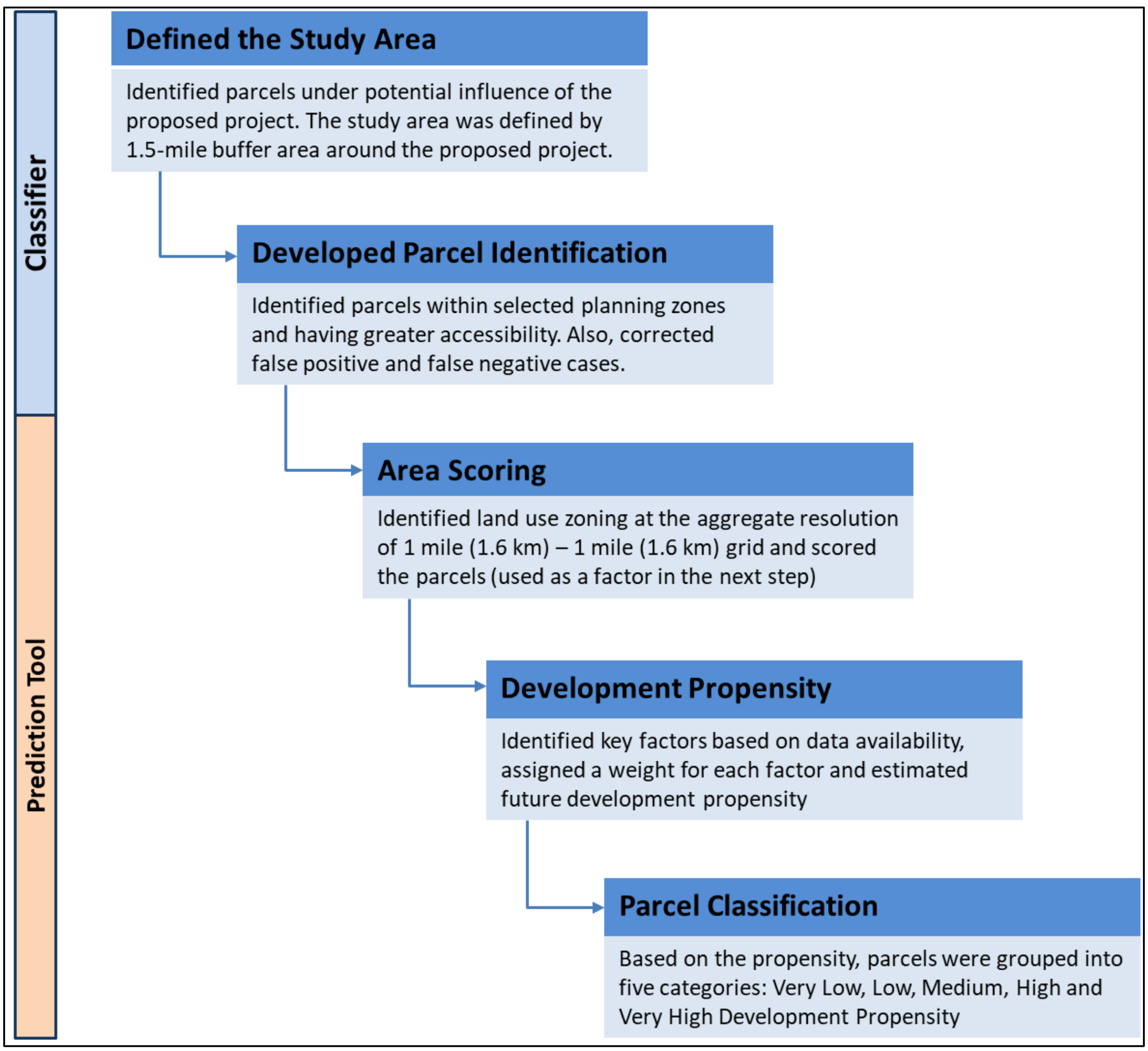


Source: Land Use Planning Zones (.shp shapefile) provided by the Cayman Islands Lands and Survey Department, 2023*

4 Methodological Framework

The developed methodological forecasting framework mainly consisted of two components. The first module is a classifier that first defines the 1.5-mile (2.4 km) buffer area surrounding the Proposed Project and then identifies the existing developed parcels within the buffer area. The second module is a prediction tool that scores the undeveloped parcels in terms of their potential to be developed in the future; and then finally classifies them into five groups: very low, low, medium, high, and very high propensity. The forecasting horizon year used in this analysis was 2074. The overall prediction framework is presented in **Figure 3**. The following subsections describe the two model components in further detail.

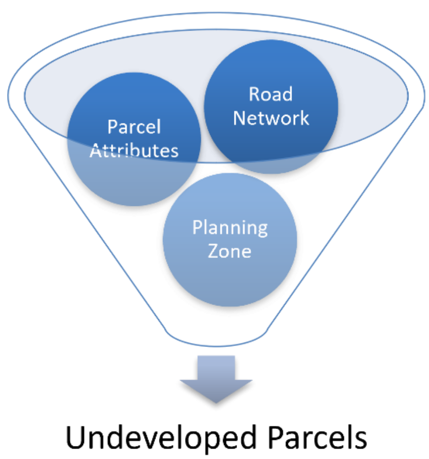
Figure 3: Forecasting Framework



4.1 Classifier

As previously described, the first step of the analysis was to define the study area and identify the developed parcels based on parcel attributes, corresponding planning zone, and access to roadways. This screening process is illustrated in **Figure 4**. Based on certain criteria (analogous to decision tree method), the parcels were grouped into two categories including developed and undeveloped parcels. The category for each of the parcels within the defined 1.5-mile (2.4 km) buffer study area were reviewed through visual examination of the ESRI imagery basemap. A review of the false positive (undeveloped but classified as developed) and false negative cases (vice versa) was completed. The initial screening by criteria (as shown in **Figure 4**) was undertaken to make the visual identification process efficient and accurate. As a result of the first component in the forecasting framework, 4,554 developed parcels (59.1% of all parcels – representing 14.4% of the buffer area) were identified.

Figure 4: Initial Screening for Developed Parcels Identification



Attributes	Conditions
Planning Zone	Beach/Resort
	Hotel/Tourism
	Institutional
	Medium Density Residential
	Low Density Residential
	Agricultural/Residential
	Neighborhood Commercial
Accessibility	Distance to nearest road<25ft
Parcel Attributes	Within buffer

4.2 Prediction Tool

The next phase of the analysis used a prediction tool to define each individual parcel’s propensity for future development. In this approach, the propensity was estimated using as a linear function of the weights and estimated measure of the factors. In the absence of historical land use data, the weights could not be estimated using any data driven approach. Instead, the EWA EIA project team in consultation with the NRA used a simplified Delphi process to assign weights of the identified factors. The following subsections describe the scoring criteria and classification methods which were employed for the analysis.

4.2.1 Factors and Weights

As previously described, the contributing factors for development propensity that were considered in the analysis included: land use zoning, planned development indicators, protected/national trust/government indicators, area score, and access to roadways. These factors were categorized into three categories:

- Planned development
- Area Type
- Access to transportation facilities

The weight factor for the elements within each category was then determined and defined in points. The individual elements and their corresponding weights are presented in **Table 2**.

Table 2: Development Propensity Factors and Weights

<table>
<tr><th colspan="2">Variable Group</th><th>Measure</th><th>Weight</th></tr>
<tr><td colspan="4">Planned Development- Max Score 20 Points</td></tr>
<tr><td colspan="2">Development plan through future year 2046</td><td>1 = having development plan
0 = none</td><td>20 pts</td></tr>
<tr><td colspan="4">Area Type – Max Score 20 Points</td></tr>
<tr><td colspan="2">Area score (from Table 1)</td><td>1: ≥ 6.41%
0.5: ≥ 5.76 - <6.41%
0: < 5.76%</td><td>10 pts</td></tr>
<tr><td colspan="2" rowspan="8">Planning zone</td><td>Agricultural/Residential</td><td>5 pts</td></tr>
<tr><td>Institutional</td><td>7 pts</td></tr>
<tr><td>Low Density Residential</td><td>7 pts</td></tr>
<tr><td>Medium Density Residential</td><td>8 pts</td></tr>
<tr><td>High Density Residential</td><td>10 pts</td></tr>
<tr><td>Beach Resort/Residential</td><td>7 pts</td></tr>
<tr><td>Hotel/Tourism</td><td>7 pts</td></tr>
<tr><td>Neighborhood Commercial</td><td>6 pts</td></tr>
<tr><td colspan="4">Access to Transportation Facilities – Max Score 20 Points</td></tr>
<tr><td colspan="2">Proximity to Undeveloped Private Right of Way</td><td>1: 0ft
0.5: >0 - <30ft
0.3: ≥30 - <120ft
0: ≥120ft</td><td>10 pts</td></tr>
<tr><td rowspan="3">Maximum Value of Access to Existing Roadway or Will T Connector or Access to Proposed Intersection,</td><td>Access to roadway</td><td>1: <40ft
0.5: ≥40 - <80ft
0.3: ≥80 - <120ft
0: ≥120ft</td><td>10 pts</td></tr>
<tr><td>Access to Will T Connector</td><td>1: <40ft
0.5: ≥40 - <80ft
0.3: ≥80 - <120ft
0: ≥120ft</td><td>10 pts</td></tr>
<tr><td>Access to proposed intersection (for Proposed Project only and if higher points than roadway)</td><td>1: ≤250ft
0.5: >250 - 500ft
0.3:>500 - 1,000ft
0: >1,000ft</td><td>10 pts</td></tr>
</table>

As presented in **Table 2**, the planned development indicator is a binary variable (0/1) providing information whether a parcel is included in a planned development. For the Planned Development category, if a parcel was identified to be within a known proposed development plan, it was considered likely to be developed in the future, and it was assigned with the maximum points (20 pts).

For the Area Type category, both the estimated area score and planning zone category were combined to estimate overall points. The maximum point allotment for this category is also 20 points, which would be met if a parcel is located within a highly developed area and the individual zone is within a high-density residential zone.

For the Access to Transportation Facilities category, the key factors included the distance to private right of way as well as access to an existing public or private roadway, access to the Will T Connector, or access to a planned intersection along the Proposed Project. In examining historic development trends associated with land development decision making, the higher the access opportunity is for a parcel, the higher the likelihood is for development. Therefore, the analysis assigned a higher score to the parcels having close or direct access to a roadway and/or proposed intersection as part of the Proposed Project. Propensity was evaluated for the Future No-Build conditions as well as for the Proposed Project. For the Future No-Build, the calculated access score depended on the proximity of each of the parcels within the study area to the existing roadway network and to private right of way. For the Proposed Project, the calculated access score depended on access to private right of way and access to the existing roadway network, the Will T Connector, or a planned intersection along the Proposed Project, whichever had the higher score. It is worth noting that some parcels within the Will T Connector buffers and planned intersection buffers have access to existing public or private roadways. As a result, their access score might not change as a result of the project.

For the parcels located within identified conservation areas, it was assumed that these parcels would not be developed in the future.

4.2.2 Development Propensity and Classification

The individual development factors previously described were used in projecting the development propensity classification of each of the undeveloped parcels within the study area. Development propensity has a linear formulation as presented in the following equation. In this equation, y_n is the development propensity for parcel n, $X_{m,n}$ is value of a factor for parcel n, and f_m is the assigned weight for a factor, m.

$$y_n = \sum_{m=1}^{M} f_m X_{m,n}$$

Based on the estimated propensity (20th, 40th, 60th and 80th percentile values for the Future No-Build), the thresholds demarcating the propensity were determined. The employment of percentile values as cutoffs was motivated from creating approximately equal sized groups of parcels for the Future No-Build conditions. The overall propensity ranges for the different groups were defined as follows:

- Very Low: <17
- Low: ≥17 – <25
- Medium: ≥25 – <27
- High: ≥27 – <32
- Very High: ≥32

These thresholds were then used to evaluate the parcels under the Proposed Project conditions, which accounted for the increase in access to transportation facilities.

5 Results Discussion

Using the prediction tool previously described in **Section 4**, future land development propensity levels were identified for the Future No-Build as well as for the Proposed Project. Parcel-level prediction results under both these conditions are presented in **Figure 5** and **Figure 6**. It was estimated that the parcels close to the Will T Connector or the planned intersections along the Proposed Project, shown in **Figure 1**, were predicted to have higher propensity. The study results indicate that 60 parcels totaling 2,442 acres (988 hectares) adjacent to and near the Proposed Project were estimated to have higher propensity classification due to the Proposed Project. The parcels with different propensity levels for the two conditions are highlighted and labelled by their propensity difference in **Figure 7**. Most of the High and Very High development propensity parcels are south of the Proposed Project or near the Western or Eastern limits of the Proposed Project. In the following subsections, the predicted area acreage under the five propensity levels, as described in **Section 4**, for various attributes are discussed.

Figure 5: Development Propensity (Future No-Build)

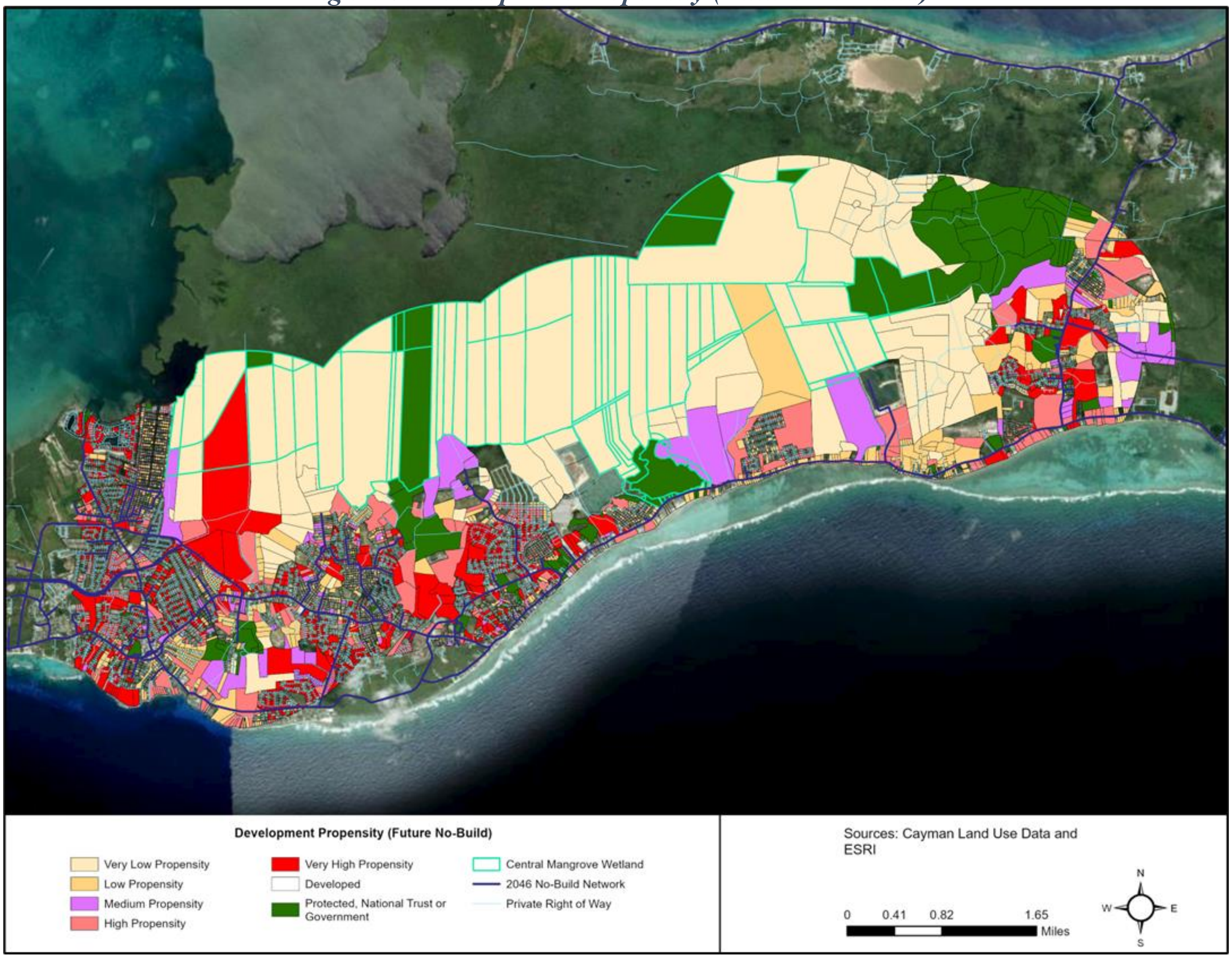


Figure 6: Development Propensity (Proposed Project)

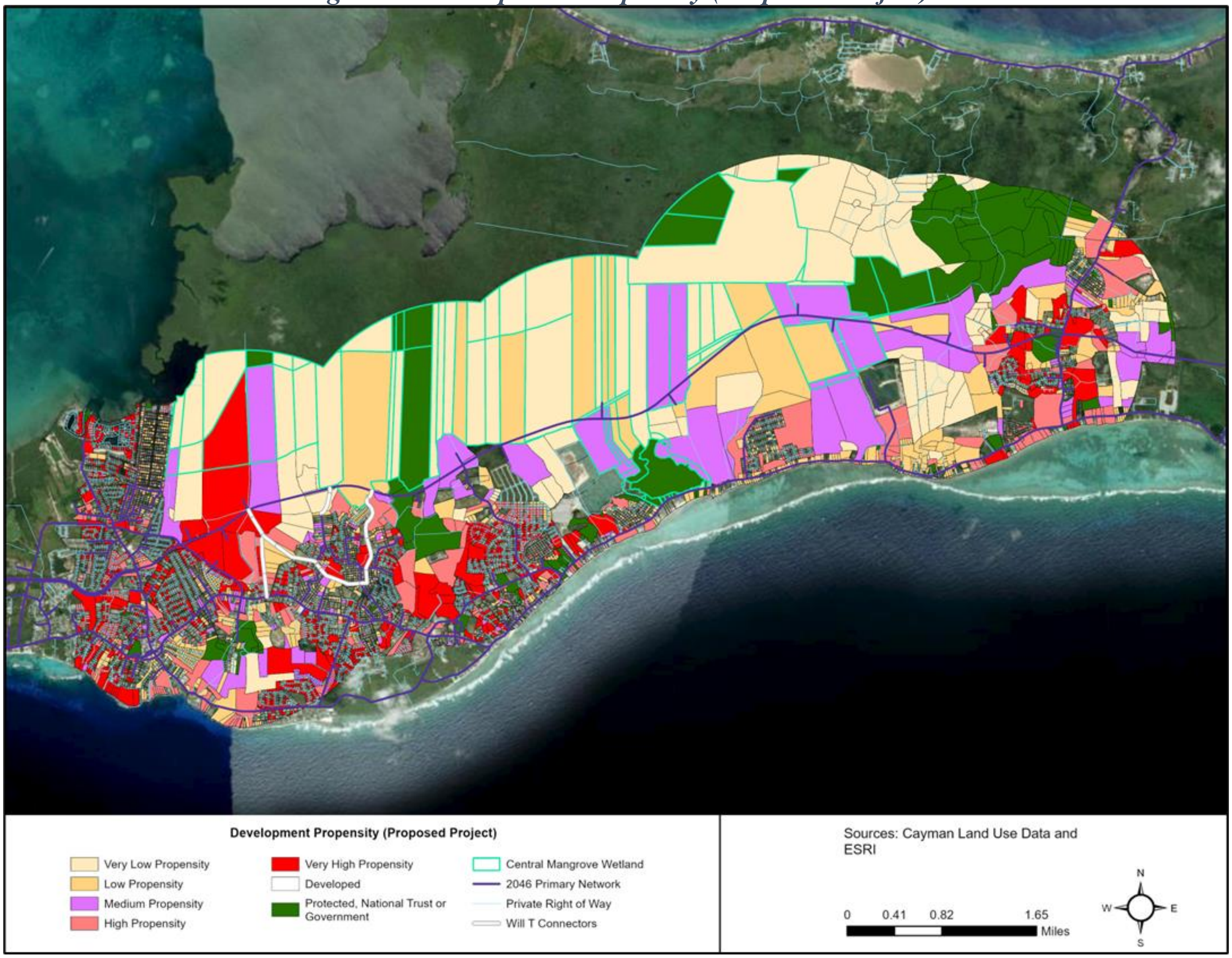
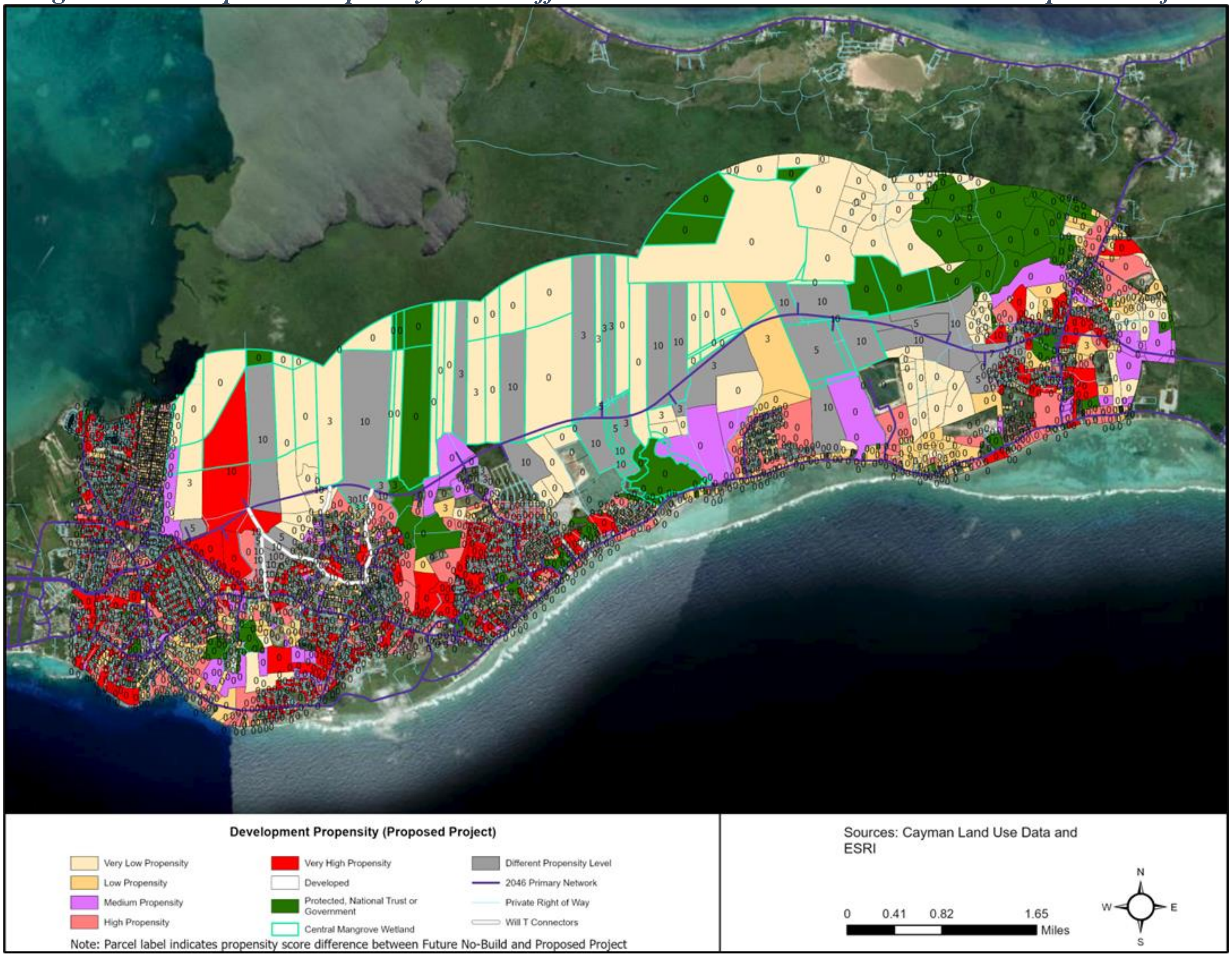


Figure 7: Development Propensity Score Difference Between Future No-Build and Proposed Project



5.1 Estimated Propensity Levels

The estimated total parcel areas for the five defined propensity levels are summarized in **Table 3**. From the comparison, the Proposed Project increases the overall acreage of Low and Medium Development Propensity by 110.4% and 132.2, respectively. The increase in acreage for High and Very High Development Propensity is significantly less at 3.8% and 3.7%, respectively.

Table 3: Estimated Propensity Levels

Propensity Level	Area in Acres		Percentage Difference in Acreage
	Future No-Build	Proposed Project	
Very Low	6,262.2	3,986.1	-36.3%
Low	1,015.8	2,137.3	110.4%
Medium	807.2	1,874.4	132.2%
High	1,009.0	1,047.5	3.8%
Very High	1,331.5	1,380.4	3.7%

5.2 Land Use Zoning Classification

Throughout the study area, there are eight land use zones, which were classified based on development propensity:

- Agricultural/Residential
- Beach Resort/Residential
- Hotel/Tourism
- Low Density Residential
- Mangrove Buffer
- Medium Density Residential
- Neighbourhood Commercial
- Public Open Space

Among these land use zones, only agricultural/residential and low-density residential zones were found to experience different propensity levels due to the Proposed Project. The propensities for each zoning category are shown in **Table 4** through **Table 11**. It is worth noting that the study area contains capacity for a substantial amount of potential development. For example, assuming the following simple factors for capacity of single-family households (HH) within residential zoning categories: Agricultural/Residential – 2 HH/Acre; Low Density Residential – 4 HH/Acre; and Medium Density Residential – 6 HH/Acre, then the Future No-Build includes the capacity for 8,316 new households in parcels with High and Very High Propensity for development. The Proposed Project includes the capacity for 8,600 new households in parcels with High and Very High Development, most of which are in the area south of the Proposed Project or near the Eastern or Western project limits.

Table 4: Propensity Comparison for Parcels within Agricultural/Residential Zones

Propensity Level	Area in Acres		Percentage Difference in Acreage
	Future No-Build	Proposed Project	
Very Low	6,080.4	3,843.9	-36.8%
Low	87.2	1,227.9	1,307.4%
Medium	724.6	1787.4	146.7%
High	48.6	81.7	68.0%
Very High	363.4	363.4	0.0%

Table 5: Propensity Comparison for Parcels within Beach Resort/Residential Zones

Propensity Level	Area in Acres		Percentage Difference in Acreage
	Future No-Build	Proposed Project	
Very Low	0.0	0.0	No Change
Low	12.9	12.9	0.0%
Medium	0.0	0.0	0.0%
High	5.8	5.8	0.0%
Very High	0.0	0.0	0.0%

Table 6: Propensity Comparison for Parcels within Hotel/Tourism Zones

Propensity Level	Area in Acres		Percentage Difference in Acreage
	Future No-Build	Proposed Project	
Very Low	0.0	0.0	No Change
Low	0.9	0.9	
Medium	0.0	0.0	
High	52.6	52.6	
Very High	10.8	10.8	

Table 7: Propensity Comparison for Parcels within Low-Density Residential Zones

Propensity Level	Area in Acres		Percentage Difference in Acreage
	Future No-Build	Proposed Project	
Very Low	117.2	77.6	-33.8%
Low	904.8	885.6	-2.1%
Medium	67.8	72.1	6.4%
High	839.5	844.9	0.7%
Very High	856.9	905.9	5.7%

Table 8: Propensity Comparison for Parcels within Mangrove Buffer

Propensity Level	Area in Acres		Percentage Difference in Acreage
	Future No-Build	Proposed Project	
Very Low	63.4	63.4	No Change
Low	0.0	0.0	0.0%
Medium	0.0	0.0	0.0%
High	0.0	0.0	0.0%
Very High	0.0	0.0	0.0%

Table 9: Propensity Comparison for Parcels within Medium Density Residential Zones

Propensity Level	Area in Acres		Percentage Difference in Acreage
	Future No-Build	Proposed Project	
Very Low	0.0	0.0	No Change
Low	5.4	5.4	0.0%
Medium	4.0	4.0	0.0%
High	17.6	17.6	0.0%
Very High	100.1	100.1	0.0%

Table 10: Propensity Comparison for Parcels within Neighborhood Commercial Zones

Propensity Level	Area in Acres		Percentage Difference in Acreage
	Future No-Build	Proposed Project	
Very Low	1.1	1.1	No Change
Low	4.6	4.6	0.0%
Medium	10.6	10.6	0.0%
High	44.9	44.9	0.0%
Very High	0.2	0.2	0.0%

Table 11: Propensity Comparison for Parcels within Public Open Space Zones

Propensity Level	Area in Acres		Percentage Difference in Acreage
	Future No-Build	Proposed Project	
Very Low	0.1	0.1	No Change
Low	0.0	0.0	0.0%
Medium	0.2	0.2	0.0%
High	0.0	0.0	0.0%
Very High	0.0	0.0	0.0%

5.3 Terrestrial Ecology Regions

For this analysis, the study area was divided into two groups based terrestrial ecology level: the Central Mangrove Wetland[1] (CMW) (see CMW areas in Figure 5 and Figure 6) and the remaining areas. For these two groups, predicted parcel-specific propensity levels were estimated and aggregated for comparison as presented in **Table 12** and **Table 13**. From the following tables, it is noteworthy that land development propensity in the CMW is significantly lower overall when compared to the remaining area. It was also estimated that land development propensity was predicted to be higher for the Proposed Project in both terrestrial ecology regions. The Proposed Project is expected to increase the number of acres with High Development Propensity by 0.1 acre in the CMW, while the Proposed Project does not impact the number of acres expected to have a Very High propensity for development. The Proposed Project is expected to have a more significant increase in the number of acres classified as Low or Medium Development Propensity.

[1] Based on Central Mangrove Wetland (*.shp shapefile) provided by the Cayman Islands Department of Environment July 2023

Table 12: Propensity Comparison for Central Mangrove Wetland

Propensity Level	Area in Acres		Percentage Difference in Acreage
	Future No-Build	Proposed Project	
Very Low	4031.6	2,403.2	-40.4%
Low	73.8	1,023.8	1,288.0%
Medium	47.2	725.5	1,437.9%
High	1.3	1.4	10.0%
Very High	129.1	129.1	0.0%

Table 13: Propensity Comparison for the Remaining Area

Propensity Level	Area in Acres		Percentage Difference in Acreage
	Future No-Build	Proposed Project	
Very Low	2,230.6	1582.9	-29.0%
Low	942.1	1,113.5	18.2%
Medium	760.1	1,148.9	51.2%
High	1,007.7	1,046.1	3.8%
Very High	1,202.4	1,251.3	4.1%

6 Conclusion

For this future year 2074 evaluation, a specific land development propensity estimation tool was developed to forecast estimated development for both Future No-Build and Proposed Project conditions. In this approach, a multi-layer forecasting tool was applied to identify developed and undeveloped parcels. Once each parcel was defined, the undeveloped parcels were classified into one of five estimated propensity levels. The propensity levels were identified based on a set of attributes including planned development through future year 2046, area type, and access to transportation measures. Overall, the Proposed Project improves transportation access, and therefore, increases the propensity for development. Based on the analysis results, the parcels south of the Proposed Project corridor are generally expected to have a higher likelihood of development when compared to those north of the Proposed Project corridor. This is mainly because of having better transportation access (both intersection access and Will T Connector), higher area scores, and lower density of protected land.

This evaluation, including the preparation of the land development projection tool, has the following limitations. Since land development is everchanging, an ArcGIS Imagery basemap was used to identify the estimated developed and undeveloped parcels. Each individual parcel is susceptible to change each day as new development occurs. If historic data becomes available, it is recommended to use data driven methods such as econometric or machine learning approaches to determine the impact of various factors considered. In addition, this study employed an "Area Score" which incorporates residential, institutional and commercial land use zones' shares within a grid. Therefore, this attribute served as a surrogate of various demographic and socio-economic factors such as population and employment. However, if further study is desired, it is highly recommended to explicitly incorporate reported demographic and socio-economic factors in the prediction methodology.