2/3/22

**Summary of methods and files delivered to County of Kauai that relate to shoreline setbacks**

***GIS Spatial Projection*:** All GIS shapefiles are in the North American Datum 1983 HARN, Zone 4N, UTM projection.

***Methods, Part 1 – Lot depth-based shoreline setbacks***

A GIS shapefile of property parcel boundaries was obtained from the County of Kaua‘i. The TMK parcel file is titled COK\_PARID.shp and has a publication date of June 30, 2021 as identified in the shapefile attributes. Coastal parcels were identified as those that were generally within a 100 foot distance from the shoreline. The 100 foot distance was selected because 100 feet is the maximum lot depth-based setback distance. The following parcel types were not included in the lot depth-based calculations: County and State roads, jetties, boat Harbors, Inland waterways, and beach accesses.

Average lot depths for each parcel were calculated based on the extents of each TMK parcel boundary, as showing in the COK\_PARID.shp GIS file. A minimum of three line segments were used to calculate the average for each parcel. Line segments were oriented roughly perpendicular to the shoreline and generally evenly spaced across the alongshore direction. For flag lots, the “pole” portion of the lot was ignored. In the case of condo units, each unit was measured separately. From the lengths of these line segments, the average lot depth for the parcel was determined.

Lot depth-based setback distances were calculated using the average lot depth and the equations introduced in County of Kauai §§ 8-27.3(c)-(d); § 8-27.4 (Ord. No. 1088). In summary, the lot depth-based setback formulas for parcels are:

* If the average lot depth < 140 ft., then the minimum setback of 60 feet applies.
* If the average lot depth falls at or between 140 ft. and 220 ft., then the lot depth setback is equal to: (average lot depth – 100 ft.)/2 + 40 ft.
* If the average lot depth > 220 ft., then the lot depth-setback is 100 ft.

A graphical, map view representation of the lot depth-based setback area for each coastal parcel was created as a GIS shapefile of polygons. This was done in the programming language Matlab, and was computed using a series of buffering, polygon subtractions, and clipping. The lot depth-based setback polygon represents a setback from the “shoreline”. Here, the vegetation line digitized by UH CGG from satellite imagery acquired in 2014 was used as a proxy for the certified shoreline. This specific imagery was used because it matches the vegetation line used in the most recent update to the erosion hazard projections that are found in the Hawaii State Sea Level Rise Viewer, so that a fair comparison can be made between the state erosion hazard projections with sea level rise, and the County of Kaua‘i setbacks that follow current legislation.

***Methods, Part 2 – Rate-based shoreline setbacks***

Rate-based setback distances were calculated using the rate-based setback equation and minimum setback distance currently in use, and introduced in County of Kauai § 8-27.3(c); § 8-27.4 (Ord. No. 1088). These equations state that rate-based setbacks are defined as 40 feet + (70 \* annual coastal erosion rate) + 20 feet, or a minimum setback of 60 feet.

A graphical map view representation of the rate-based setback areas was created as a GIS shapefile of polygons, which depict rate-based setback areas for contiguous sandy beach areas. This was done in the programming language Matlab, and manually edited to remove transect projections that cross each other, causing a jagged anomaly in the alongshore projection. The rate-based setback polygon represents a setback from the “shoreline”. Here, the vegetation line digitized by UH CGG from satellite imagery acquired in 2014 was used as a proxy for the certified shoreline. This specific imagery was used because it matches the vegetation line used in the most recent update to the erosion hazard projections that are found in the Hawaii State Sea Level Rise Viewer, so that a fair comparison can be made between the state erosion hazard projections with sea level rise, and the County of Kaua‘i setbacks that follow current legislation.

***Description of Table*:** The UH Coastal Geology Group created a table containing information about shoreline change, various setbacks, and other identifying information.

Table columns are:

* **Island**: Island name
* **Region**: NKauai, EKauai, SKauai, or WKauai
* **AreaName**: General area name used in UH CGG older map products
* **TransectID**: Transect ID number. Each transect on the island has a unique number.
* **Long term rate (ft/yr)**: Long-term rate in ft/yr
* **HI SLR Erosion Haz 2100 80% (ft)**: Distance from the 2014 veg line to the “red line” in the Hawaii State SLR viewer, along transect line orientation.
* **CoK Current Rate Setback (ft)**: Current County of Kaua‘i rate-based setback value, where setback = 40 ft + (70 x rate) + 20 ft, or a minimum of 60 ft.
* **CoK Current Lot Depth Setback (ft)**: Current County of Kaua‘i lot depth setback value.
* **CoK Current Lot Depth Setback Dist Along Transect (ft)**: This is the distance from the veg line to the lot depth setback polygon, following the transect orientation. So, if you were to extend the transect line inland, and intersect it with the lot depth setback polygon, the distance along the extended transect line from the veg line to the end of the setback polygon would be the distance in this column. It might be different from the calculated lot depth setback for a couple of reasons: first, the transect orientation is *generally* perpendicular to the shoreline, but it follow a much smoother coastal outline; in contrast, the lot depth setback buffer extends inland following the curvature of the veg line closely. Second, the lot depth setback polygon is cropped to match the parcel shape, which might not extend inland as far as the calculated setback value.
* **Average lot depth (ft)**: Average lot depth based on a minimum of 3 parcel lengths, spaced roughly equally apart.
* **Parcel ID (PARID)**: Parcel ID attached to the TMK shapefile. I believe that it gives condo units a unique number.
* **TMK Number**: TMK number attached to the TMK shapefile.
* **Davidson-Arnott addl. SLR retreat (ft)**: This is an estimate of the shoreline retreat due to additional sea level rise over the 70 year period from 2022 to 2092 using the Bruun Rule type formula presented in Davidson-Arnott (2005). The formula is retreat = (1/slope) x SLR, where the slope is determined as the slope between the low water mark and the depth of closure, and the SLR is the additional sea level rise above historical sea level trends. The amount of sea level rise over the 70 year period is the change in projected sea level from the IPCC AR5 RCP 8.5 upper sea level scenario, which as 2.0463 ft.

***Description of Shapefiles*:** The UH Coastal Geology Group created a total of five shapefiles related to shoreline setbacks: four files related to lot depth-setback, and one file related to rate-based setback.

**Filename:** **lot\_depth\_setback.shp**

* **Description: *Polygon shapefile depicting the lot depth-based setback for each coastal parcel, with one polygon filling the entire setback area within the parcel (both mauka and makai of the shoreline).*** Coastal parcels were those determined to be generally within a 100 foot minimum distance from the shoreline because 100 feet is the maximum lot depth-based setback distance. The following parcels are not included in the lot depth-based calculations: County and State roads, jetties, boat Harbors, Inland waterways, and beach accesses. Average lot depths for each parcel were calculated based on the TMK parcel boundary, as depicted in the TMK boundary shapefile titled “COK\_PARID.shp” with the publication date of June 30, 2021. Lot depth-based setback distances were calculated using the average lot depth and the equations introduced in County of Kauai §§ 8-27.3(c)-(d); § 8-27.4 (Ord. No. 1088). A minimum of three line segments were determined for each parcel that were oriented roughly perpendicular to the shoreline, and generally evenly spaced across the alongshore direction. For flag lots, the “pole” portion of the lot was ignored. In the case of condo units, each unit was measured separately. The landward extent of the lot depth-based setback polygon represents a setback distance of “LD\_SETBK\_FT” from the shoreline. Here, the vegetation line digitized by UH CGG from satellite imagery acquired in 2014 was used as a proxy for the certified shoreline; this specific imagery was used because it matches the vegetation line used in the most recent update to the erosion hazard projections that are found in the Hawaii State Sea Level Rise Viewer, so that a fair comparison can be made between the erosion hazard projections, and the County of Kaua‘i setbacks that follow current legislation.
* **Attributes** for each polygon:
  + All attributes from the original TMK parcel shapefile (e.g., TMK, PARID, TAXACRES)
  + CGG\_INDEX: Parcel index used only by the University of Hawai‘i Coastal Geology Group.
  + AVE\_DEP\_M: Average lot depth, in meters.
  + AVE\_DEP\_FT: Average lot depth, in feet.
  + ALL\_DEPS\_M: All lot depths, in meters, used to calculate the AVE\_DEP\_M.
  + ALL\_DEPS\_FT: All lot depths, in feet, used to calculate the AVE\_DEP\_M.
  + LD\_SETBK\_FT: Lot depth setback distance, in feet, following the equations introduced in County of Kauai §§ 8-27.3(c)-(d); § 8-27.4 (Ord. No. 1088). The lot depth-based setback formulas for parcels with the following average lot depths are:
    - If average lot depth < 140 ft., then the minimum setback of 60 feet applies.
    - If 140 ft. <= average lot depth <= 220 ft., then the lot depth setback = (average lot depth – 100 ft.)/2 + 40 ft.
    - If average lot depth > 220 ft., then the lot depth-setback is 100 ft.

**Filename: lot\_depth\_setback\_with\_shore.shp**

* **Description**: ***Polygon shapefile depicting the lot-depth-based setback for each coastal parcel, with separate polygons for areas that are (1) landward/mauka of the shoreline, and (2) seaward/makai of the shoreline.*** Coastal parcels were those determined to be generally within a 100 foot minimum distance from the shoreline because 100 feet is the maximum lot depth-based setback distance. The following parcels are not included in the lot depth-based calculations: County and State roads, jetties, boat Harbors, Inland waterways, and beach accesses. Average lot depths for each parcel were calculated based on the TMK parcel boundary, as depicted in the TMK boundary shapefile titled “COK\_PARID.shp” with the publication date of June 30, 2021. Lot depth-based setback distances were calculated using the average lot depth and the equations introduced in County of Kauai §§ 8-27.3(c)-(d); § 8-27.4 (Ord. No. 1088). A minimum of three line segments were determined for each parcel that were oriented roughly perpendicular to the shoreline, and generally evenly spaced across the alongshore direction. For flag lots, the “pole” portion of the lot was ignored. In the case of condo units, each unit was measured separately. The landward extent of the lot depth-based setback polygon represents a setback distance of “LD\_SETBK\_FT” from the shoreline. Here, the vegetation line digitized by UH CGG from satellite imagery acquired in 2014 was used as a proxy for the certified shoreline; this specific imagery was used because it matches the vegetation line used in the most recent update to the erosion hazard projections that are found in the Hawaii State Sea Level Rise Viewer, so that a fair comparison can be made between the erosion hazard projections, and the County of Kaua‘i setbacks that follow current legislation.
* **Attributes** for each polygon:
  + All attributes from the original TMK parcel shapefile (e.g., TMK, PARID, TAXACRES)
  + CGG\_INDEX: Parcel index used only by the University of Hawai‘i Coastal Geology Group.
  + AVE\_DEP\_M: Average lot depth, in meters.
  + AVE\_DEP\_FT: Average lot depth, in feet.
  + ALL\_DEPS\_M: All lot depths, in meters, used to calculate the AVE\_DEP\_M.
  + ALL\_DEPS\_FT: All lot depths, in feet, used to calculate the AVE\_DEP\_M.
  + LD\_SETBK\_FT: Lot depth setback distance, in feet, following the equations introduced in County of Kauai §§ 8-27.3(c)-(d); § 8-27.4 (Ord. No. 1088). The lot depth-based setback formulas for parcels with the following average lot depths are:
    - If average lot depth < 140 ft., then the minimum setback of 60 feet applies.
    - If 140 ft. <= average lot depth <= 220 ft., then the lot depth setback = (average lot depth – 100 ft.)/2 + 40 ft.
    - If average lot depth > 220 ft., then the lot depth-setback is 100 ft.
  + IN\_SHORE: Indicates whether the area is inland or seaward of the shoreline.
    - IN\_SHORE = 1 indicates inland (*mauka*) of the shoreline
    - IN\_SHORE = 0 indicates seaward (*makai*) of the shoreline

**Filename:** **tmk\_parcels\_with\_lot\_depth.shp**

* **Description**: ***Polygon shapefile of coastal parcels with attached attributes of average lot depths and lot depth-based setback distances.*** Coastal parcels were those determined to be generally within a 100 foot minimum distance from the shoreline because 100 feet is the maximum lot depth-based setback distance. The following parcels are not included in the lot depth-based calculations: County and State roads, jetties, boat Harbors, Inland waterways, and beach accesses. Average lot depths for each parcel were calculated based on the TMK parcel boundary, as depicted in the TMK boundary shapefile titled “COK\_PARID.shp” with the publication date of June 30, 2021. Lot depth-based setback distances were calculated using the average lot depth and the equations introduced in County of Kauai §§ 8-27.3(c)-(d); § 8-27.4 (Ord. No. 1088). A minimum of three line segments were determined for each parcel that were oriented roughly perpendicular to the shoreline, and generally evenly spaced across the alongshore direction. For flag lots, the “pole” portion of the lot was ignored. In the case of condo units, each unit was measured separately.
* **Attributes** for each polygon:
  + All attributes from the original TMK parcel shapefile (e.g., TMK, PARID, TAXACRES)
  + CGG\_INDEX: Parcel index used only by the University of Hawai‘i Coastal Geology Group.
  + AVE\_DEP\_M: Average lot depth, in meters.
  + AVE\_DEP\_FT: Average lot depth, in feet.
  + ALL\_DEPS\_M: All lot depths, in meters, used to calculate the AVE\_DEP\_M.
  + ALL\_DEPS\_FT: All lot depths, in feet, used to calculate the AVE\_DEP\_M.
  + LD\_SETBK\_FT: Lot depth setback distance, in feet, following the equations introduced in County of Kauai §§ 8-27.3(c)-(d); § 8-27.4 (Ord. No. 1088). The lot depth-based setback formulas for parcels with the following average lot depths are:
    - If average lot depth < 140 ft., then the minimum setback of 60 feet applies.
    - If 140 ft. <= average lot depth <= 220 ft., then the lot depth setback = (average lot depth – 100 ft.)/2 + 40 ft.
  + If average lot depth > 220 ft., then the lot depth-setback is 100 ft.

**Filename:** **tmk\_lot\_depth\_lines.shp**

* **Description**: ***Line shapefile depicting the line segments used to determine lot depths for each parcel.*** A minimum of three line segments were determined for each parcel that were oriented roughly perpendicular to the shoreline, and generally evenly spaced across the alongshore direction. For flag lots, the “pole” portion of the lot was ignored. In the case of condo units, each unit was measured separately.
* **Attributes** for each line:
  + All attributes from the original TMK parcel shapefile (e.g., TMK, PARID, TAXACRES)
  + LINE\_LEN\_M: Length of line, in meters.
  + LINE\_LEN\_FT: Length of line, in feet.

**Filename: Kauai\_existing\_rate\_based\_setback.shp**

* **Description**: ***Polygon shapefile depicting the rate-based setback for contiguous sandy beach areas, following the current County of Kaua‘i shoreline setback rules.*** Rate-based setback distances were calculated using the rate-based setback equation and minimum setback distance introduced in County of Kauai § 8-27.3(c); § 8-27.4 (Ord. No. 1088). These equations state that rate-based setbacks are defined as 40 feet + (70 \* annual coastal erosion rate) + 20 feet, or a 60 foot minimum. The landward extent of each rate-based setback polygon represents the setback line, determined as the setback distance from the shoreline. Here, the vegetation line digitized by UH Coastal Geology Group from satellite imagery acquired in 2014 was used as a proxy for the certified shoreline; this specific imagery was used because it matches the vegetation line used in the most recent update to the erosion hazard projections that are found in the Hawaii State Sea Level Rise Viewer, so that a fair comparison can be made between the State erosion hazard projections, and the County of Kaua‘i setbacks that follow current legislation. No attributes were created each polygon.