GIS Protocols and Procedures for Compliance with the Mongolian Offset Guidelines using the Mitigation Design Tool

The Nature Conservancy

Contents

Introduction

Within Mongolia, companies whose business practices impact the land and alter the natural state of the environment are required by law to offset those impacts. Companies may work directly with Aimag and/or National regulators (i.e. Ministry of Environment and Green Development - MEGD) to create an extensive and detailed offset plan or they can follow Section 3.3.6 of the Mongolian Offset Guidelines (MOG) to derive a yearly offset compensation value which is used to match equivalent offset actions as determined by both the company and regulator. Following the MOG, companies calculate required offset compensation value in three main steps: 1) Identify the area that is likely to be affected by the proposed project (i.e. map the development footprint and its direct supporting infrastructures, delineate an impact area, and determine the magnitude of these impacts); 2) Use this impact area to calculate the total offset units necessary to meet the offset regulation; and 3) Calculate total yearly offset compensation value. For each step, the MOG defines methods for calculating and fulfilling these requirements. In order to follow these steps, it is however necessary to be well versed in using GIS and fully understand all data used in the analysis. Without this knowledge, the regulation can be difficult to implement leading to inconsistencies in those trying to follow the law.

To meet this implementation gap, The Nature Conservancy (TNC) in partnership with the Mongolia Ministry of Environment and Green Development (MEGD) produced a series of documents and GIS tools to provide companies with the ability to easily and efficiently determine their offset compensation requirements. This endeavour was part of a larger effort of building capacity within MEGD to support landscape-level conservation in the southern Gobi and was directly financed by the European Bank for Reconstruction and Development (EBRD) Shareholders Special Funds. Specifically TNC assisted MEGD and other stakeholders in the identification, review, assessment, implementation, and monitoring of mitigation and other conservation measures. Four main tasks were identified within this project: 1) conduct an analysis of habitat connectivity of Asiatic Wild Ass (Equus hemionus, or khulan) in the Eastern Gobi Desert region; 2) create a mitigation design tool (MDT); 3) assess alternatives and logistical constraints of regional traffic; and 4) provide training for a) performing habitat connectivity analyses, b) using MDT, and c) assessing regional soil conditions in the mineralized zones of the Gobi Desert.

This document focuses on the GIS methods, procedures and data necessary to meet the MOG requirements and how MDT can be used to avoid the manual GIS tasks identified in the regulation. In order to effectively apply MDT, users will still need to be familiar with GIS concepts and principles. Throughout this document, explicit steps and

tutorials will be described using two GIS software programs, ArcGIS and QGIS.   ArcGIS is proprietary GIS software produced by ESRI (see http://www.esri.com/arcgis). QGIS is open source GIS software (see http://www.qgis.org). This document along with data and tools supporting this project can be accessed at Mongolian Mitigation Design Tool website (MMDT Web Portal - http://s3.amazonaws.com/DevByDesign-Web/MonOffsetDesign/index.html). This website will be updated periodically as new tools and data become available in support of the MOG.

Mitigation Design Tool Overview

The Mitigation Design Tool (MDT) provides any company, consultant and/or government official with the resources necessary to apply mitigation principals as they relate to the MOG regardless of their GIS capabilities and software. Both a desktop version using ArcGIS (i.e. MDT-Desktop) and an internet version (i.e. MDT–Web) of MDT have been created with each having similar functionality.   While the MDT-Desktop provides a few more tools, both produce the same necessary data to comply with the MOG.

MDT - Desktop

The MDT-Desktop (Fig. 1) has four main toolsets; Land Disturbance and Impact Tools, Offset Tools, Supplementary Avoidance Tools, and Update Tools. The *Land Disturbance and Impact Tools* assist users in following standards set such as projection and attribution for digitally creating within GIS land disturbances (LDs) data and then use these spatial data to create a project impact dataset. The *Offset Tools* use the project impact dataset to derive an offset cost report and identify potential offset locations. The *Supplementary Avoidance Tools* allow

Fig. 1 MDT-Desktop ArcGIS Toolbox

users to relatively compare potential offset costs for either leases and or planned LDs. By providing these tools, users can look at ways to potentially limit their offset costs while also avoiding important landscapes and habitat within Mongolia.   Finally the *Update Tools* help users stay current with the application database without having to reinstall the MDT application. Each tool is described in detail within the MDT - Desktop Help document. The tool and documentation can be downloaded at the Mongolia Mitigation Design Tool Web Portal. Users will download a zip file containing the toolbox, scripts and data necessary run all the tools. For most tools to run, the MDT-Desktop not only requires ArcGIS 10.1 or higher versions but also the ESRI Spatial Analyst extension.

MDT - Web

The web-based mitigation tool (Fig. 2) allows users via the Internet to produce data and reports necessary to comply fully with the MOG. Users will be required to create input data (i.e. land disturbances) and upload these data in a shapefile format. This document describes how to accomplish this task using QGIS however any available mapping or design software can be used which allows for data to be exported in a shapefile format.   The input data are processed by a remote TNC server with the web application emailing users a zipped file containing a raster dataset representing the project impact area, an html file containing the MDT offset report, and all supporting shapefiles (i.e. offset site selections and input land disturbances). None of the data uploaded by the users is saved to the server except temporarily during the processing of data.   A full description of the MDT-Web and how to use it is available in the: MDT-Web Help documentation. The application and documentation can also be found at the Mongolia Mitigation Design Tool Web Portal.

Fig. 2 MDT-Web

Step 1 - Mapping Land Disturbances

The first required step by the MOG is for companies to map the LDs associated with their planned development. LDs are any infrastructures (e.g. roads, pipelines, buildings), operations (e.g. mining pits, overburden piles, settling ponds) and/or settlements (e.g. work camps, towns) which are planned for the support and operation of the developed area. Mapping and attributing these data accurately are critical since these data derive the impact area and magnitude and ultimately set the overall offset compensation value.

Format and Positional Accuracy

There are many methods and tools that can be used to locate and map planned LDs. Regardless of how LDs are originally mapped, users will need to have the ability to convert their data to either the ESRI shapefile or geodatabase format.   Shapefiles are an open GIS format created by ESRI which can be read and exported by most GIS software and are the preferred alternative for all MDT tools.   For more information on shapefiles see http://doc.arcgis.com/en/arcgis-online/reference/shapefiles.htm. To convert from either an AutoCad DXF file or GPX GPS file, on-line tools are available here: http://www.gisconvert.com/ or users can follow steps found within ArcGIS help documentation on "Import from CAD (Conversion)" and "GPX To Features (Conversion)," respectively. For QGIS users, documentation on shapefile conversion also exists for DXF files at http://docs.qgis.org/2.8/en/docs/user_manual/plugins/plugins_dxf2shape_converter.html?highlight=dxf and GPX files at http://docs.qgis.org/2.8/en/docs/user_manual/working_with_gps/plugins_gps.html.

To digitally represent LDs, MDT requires these features be either a linear or area (i.e. polygon) feature. Mapping of these features needs to be done at a minimum positional accuracy of 10 meters which is achievable by most recreational-level GPS receivers or by screen digitizing from aerial photography with a minimum of 5 meter resolution (i.e. pixel size of 25 m^2 or less). Mapping with less positional accuracy (e.g. 50 meters) will produce inaccurate representation of the LDs which could lead to higher compensation requirements than necessary. MDT does not limit users from running any tool based on positional accuracy since during the planning phase it may be necessary to quickly assess potential offset compensation costs. All spatial data used by MDT must have a coordinate system associated with it. MDT uses the projected coordinate system - UTM, Zone 48N projection based on the WGS 1984 datum (i.e. ESRI name: WGS_1984_UTM_Zone_48N or EPSG WKID: 32648). It is recommended all spatial data being used by MDT also use this coordinate system to ensure proper datum transformations of original data and avoid other potential projection issues.

Feature requirements

All LDs must be represented by either a linear or area (polygon) features and be contained within the appropriate data format (e.g. shapefile).   An exception to this requirement occurs when LDs are within a fenced area. These features can be excluded as long as the fenced area completely contains these LDs and are only accessible through gated entrances. All other LDs outside of the fenced area must still be mapped and used in the analysis.

Attribution requirements

To appropriately run MDT, users must maintain strict attribute standards associated with mapping LDs. Each linear or area feature must have an attribute which classifies that LD as one of the predefined types, as listed by Table 1 and Table 2. At minimum, a numeric code field must be added and each feature must have one of the coded values listed in the tables below associated with it.

Table 1. Linear LD Types. Linear features representing land disturbances for MOG. Table identifies the required coded value, the type of LD and the definition of each type.

LD Code	LD Type	Definition
1	Transmission Lines	Any power line, either high or low voltage
2	Pipeline – Elevated	Any pipeline distributing any commodity or product which is elevated above the ground
3	Pipeline - Ground Level	Any pipeline distributing any commodity or product which is on the ground
4	Pipeline – Buried	Any pipeline distributing any commodity or product which is buried below ground
5	Roads – Paved	Any paved roadway – if divided roadway, each lane must be represented
6	Roads - Improved Dirt	Any improved roadway that is not paved – if divided roadway each lane must be represented
7	Roads - Dirt single-track	Any single – track dirt roadway which cannot eventually turn into a multi-track dirt roadway or will remain single-track
8	Roads - Dirt multi-track	Any multi – track dirt roadway. Feature needs to represent the center or most used track.
9	Railroad	Railroad tracks
10	Other Linear Infrastructures	Any other linear feature not described above.

Table 2. Area LD Types. Area features representing land disturbances for MOG. Table identifies required coded value, the type of LD and the definition of each type.

LD Code	LD Type	Definition
1	City	Permanent settlement with a population of greater than 5000 people
2	Large Town	Permanent settlement with a population ranging from 1000 to 5000 people
3	Town	Permanent settlement with a population less than 1000 people
4	Temporary Camp	Temporary worker camp
5	Fenced Area	Enclosed fenced area of operations. If other disturbance features found within fenced area, these do not need to be included in either the linear or area disturbance features.
6	Office Facilities	Buildings used for offices
7	Processing Facilities	Buildings used in processing
8	Storage	Storage buildings
9	Gas Station	Facility used for fueling vehicles
10	Mining Pit	Planned mining pit, all area to be mined.
11	Oil Pad	Oil pad
12	Piles	Tailings, overburden, waste and other piles
13	Ponds	Settling, processing, storage, other ponds
14	Parking – Paved	Paved parking
15	Parking – Dirt	Dirt parking
16	Airport strip	Airport landing strip
17	Airport buildings	Airport support buildings
18	Other Area Infrastructures	Any other area type feature not defined.
19	Leach Pad	Area where mined ore is crushed and irrigated with a leach solution to dissolve the metals.

MDT Tools and Methods for Mapping Land Disturbances

The MDT-Desktop has two tools which assist in mapping LDs and following the necessary standards; Step *1a – Create Land Disturbance Data* and the *Step 1b – Check Land Disturbance Data* (see MDT-Desktop Help Document for more information). The *Step 1a – Create Land Disturbance Data* tool creates a file geodatabase within a user-defined folder and creates both LD feature classes (i.e. area and linear) within the geodatabase. Additionally it creates attribute domains within the geodatabase and assigns these to the appropriate feature class field. This gives users guidance on selecting the LD type identified in Tables 1 and 2 when digitizing these features.

The *Step 1b – Check Land Disturbance Data* tool allows users to check their LD data for errors or missing parameters prior to using these data in other tools within the MDT-Desktop. The tool produces warning messages when selected LDs have issues which will be handled by the application and produces error messages for those data errors which will not allow for the LDs to be used by the application. This tool mainly supports users who import data from other applications and want to run the MDT-Desktop.

The creation of LD data is not supported within the MDT-Web application however steps for data creation are explained for using QGIS (see QGIS Steps with MDT-Web Tool and Appendix F – Tutorial for QGIS 2.8 Users for more information). The *Upload and Check Land Disturbance Data* tool within the MDT-Web allows users to upload LD data created from GIS or design software to the web tool and then check their LD data for attribution errors prior to using these data. The tool allows users to upload a zip file containing one or two shapefiles representing the LDs. The user then identifies the attribute field containing LD codes associated with each feature (i.e. Tables 1 and 2).

Finally if errors are found, the application will identify these errors so the user can modify their data to meet the attribute standards. For more information on this tool see the MDT-Web Help document.

Step 2 - Calculate Project Impact Area and Magnitude

The second step of the MOG requires companies to calculate the cumulative area of impact by the planned development and categorize this area into three magnitude zones of high, medium, and low. This is accomplished in a four-step process; 1) the impact area for each LD is mapped based on the assigned maximum impact distance, 2) within the LD impact area, a distant decay function is used to assign continuous impact magnitude values based on the distance from the LD and assigned impact weight, 3) all continuous impact values are combined with the highest impact magnitude value, in cases of overlapping values, being assigned , and 4) the combined continuous impact values are placed into the three magnitude zones of high, medium, and low.

Assigned LD Impact Parameters

To derive a final project impact area and magnitude, three parameters needed to be assigned for each identified LD type; maximum impact distance, impact weight, and a distant decay function (Table 3). All three of these variables were based on expert opinions related to development within Mongolia. The maximum impact distance is an estimate in meters on the distance from an LD where impacts are no longer influenced by that particular disturbance. The impact weight, limited to one of three values (i.e. 300, 200, and 100) differentiates the intensity the disturbance has on the environment in comparison to other disturbances with a weight of 300 being the highest potential weight. The distance decay function can be one of three types (i.e. gradual, moderate, and abrupt) and are used to calculate the continuous impact values for each LD. These exponential formulas produce impact values that decrease as the distance from the disturbance increases. The rate at which values decrease varies based on the selected decay function. For example, the abrupt formula produce continuous impact values that rapidly decreases while the gradual formula displays a more gradually decrease in the values as moving away from the disturbance (Fig. 3).

Table 3. LD types with assigned maximum impact distance in meters, impact weight, and distant decay function.

Group	Land Disturbance Type	Feature Type	LD Code	Max Impact Distance (m)	Impact Weight	Distant Decay Function
Settlements	City	Area	1	10,000	300	Gradual
	Large Town	Area	2	5,000	300	Gradual
	Town	Area	3	2,500	300	Gradual
	Temporary Camp	Area	4	1,000	300	Gradual
Operations	Fenced Area	Area	5	1,000	300	Moderate
	Office Facilities	Area	6	100	300	Gradual
	Processing Facilities	Area	7	300	300	Gradual
	Storage	Area	8	100	300	Moderate
	Gas Station	Area	9	100	300	Gradual
	Mining Pit	Area	10	1,000	300	Gradual
	Oil Pad	Area	11	150	300	Moderate
	Piles	Area	12	300	300	Gradual
	Ponds	Area	13	100	300	Moderate
	Leach Pad	Area	19	300	300	Gradual
	Parking - Paved	Area	14	100	300	Abrupt
	Parking - Dirt	Area	15	200	300	Gradual

	Other Operations	Area	18	100	300	Moderate
Infrastructure	Airport strip	Area	16	100	300	Gradual
	Airport buildings	Area	17	100	300	Moderate
	Transmission Lines	Linear	1	100	100	Abrupt
	Pipeline - Elevated	Linear	2	100	200	Abrupt
	Pipeline - Ground Level	Linear	3	100	300	Abrupt
	Pipeline - Buried	Linear	4	100	100	Abrupt
	Roads - Paved	Linear	5	100	300	Abrupt
	Roads - Improved Dirt	Linear	6	200	200	Moderate
	Roads - Dirt single-track	Linear	7	100	100	Moderate
	Roads - Dirt multi-track	Linear	8	250	100	Gradual
	Railroad	Linear	9	100	300	Abrupt
	Other Linear Infrastructures	Linear	10	100	200	Moderate
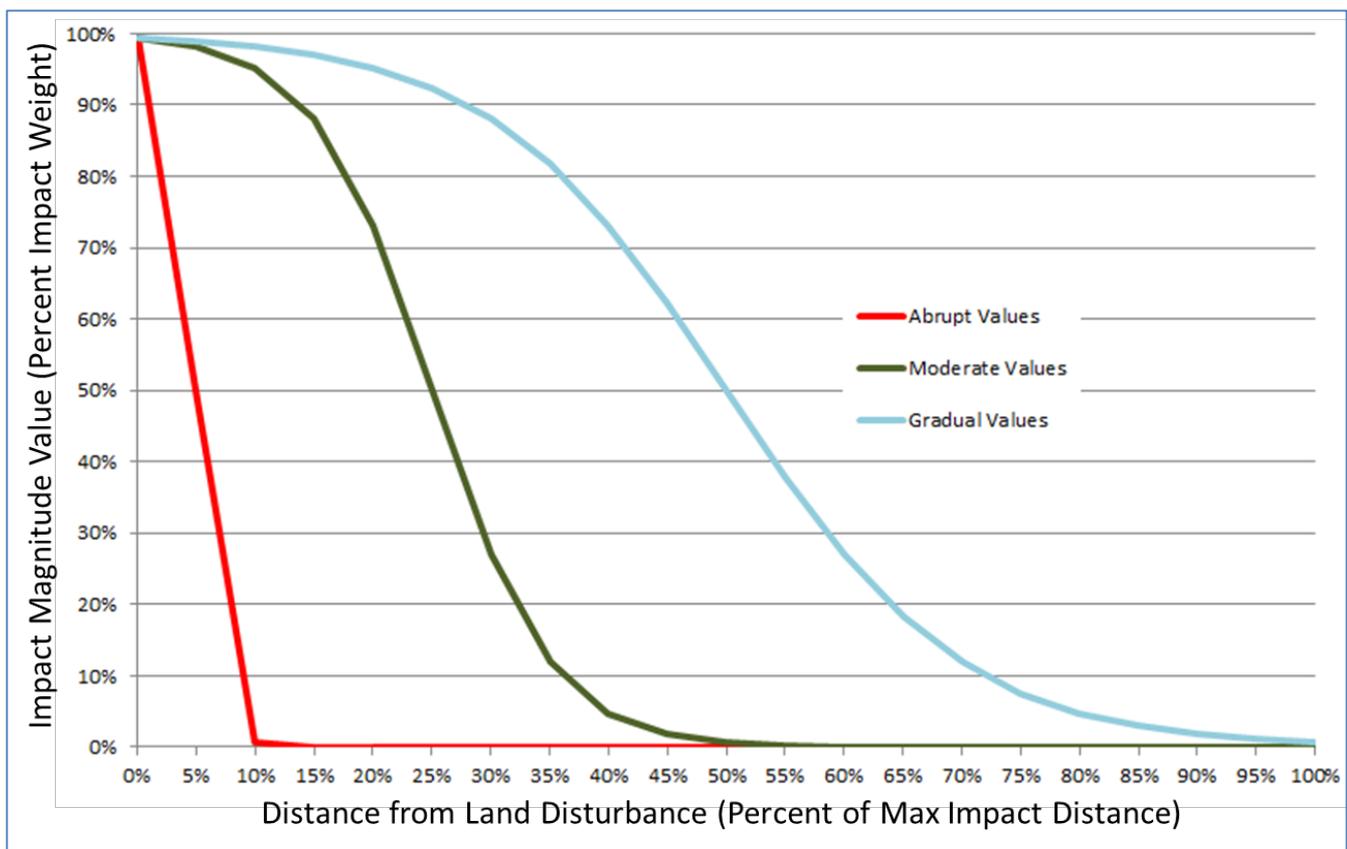
Fig. 3 – Relative distance decay function curves showing the impact value as a percent of the assigned disturbance weight (i.e. y-axis) and distance as a percent total assigned impact distance (i.e. x-axis). For example if a disturbance had an assigned impact weight of 100, maximum impact distance of 500 meters, and a decay function of gradual, the impact value at 250 meters away from the disturbance (i.e. 50% total distance) would be 50 or 50% of 100.

MDT Methods for Calculating Project Impact Area and Magnitude

Both the MDT-Desktop and MDT-Web use the same method to calculate the project impact area and magnitude. Each uses the input LD data and assigned LD impact parameters (i.e. impact distance, impact weight, and decay function) to derive the impact area following the process described below.

LD Impact Area

To calculate the LD impact area, a Euclidian distance raster is generated with a 10 meter resolution. This raster identifies the straight-line distance any raster pixel's cell centroid is from the LD. The values of this raster can range from 0, indicating the location of the disturbance, up to the maximum impact distance assigned for the LD. A 10

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meter resolution was selected due to being similar to the width of the smallest mapped linear LDs (i.e. dirt-roads, pipelines, etc.).

LD Continuous Impact Magnitude Raster

Once the LD impact area is produced, this raster dataset is then used to derive a continuous impact magnitude raster for each LD. This process is done by selecting the assigned distance decay function for an LD and applying it to each pixel value (i.e. Euclidian distance) found within the LD impact area. The formulas and variables associated with each are listed below:

Abrupt: $(1 / (1 + \text{Exp} (((\textbf{Distance} / (\textbf{Max\_Distance}/20)) - 1) * 5))) * \textbf{Weight}$

Moderate: $(1 / (1 + \text{Exp} ((\textbf{Distance} / (\textbf{Max\_Distance}/20)) - 5))) * \textbf{Weight}$

Gradual: $(1 / (1 + \text{Exp} (((\textbf{Distance}/ (\textbf{Max\_Distance}/20)) - 10) * 0.5))) * \textbf{Weight}$

Variable Descriptions: **Distance** = distance from disturbance in meters,
Max_Distance = assigned maximum impact distance for disturbance in meters,
Weight = assigned impact weight

Each formula relies on three variables: 1) the distance from the disturbance, 2) the assigned maximum impact distance, and 3) the weight for a given land disturbance. Before multiplying the weight, each formula calculates an inversed, exponential value between zero and one with the value approaching zero as it moves away from the LD and reaches the maximum impact distance. This fractional value is then multiplied by the impact weight to assign the continuous impact magnitude value for that particular distance from the disturbance.

Final Project Impact Area and Magnitude

Once the continuous impact magnitude raster has been calculated for each disturbance, these raster datasets are merged to create one combined continuous impact magnitude raster. For those overlapping raster pixels with assigned values, the highest impact magnitude value was selected and placed in the final impact raster. This raster was then classified by equal intervals into three categories: high, medium, and low. This reclassifies the highest 1/3 of impact magnitude values in the high category, the next 1/3 in medium, and the lowest 1/3 of values in the low category. To calculate final offset costs, cell values were assigned to one of three impact magnitude zones: high-30, medium-20, and low-10 (Fig. 4).

Land Disturbance
Mining Pit Example
Project Impact Area
30 - High Impact
20 - Medium Impact
10 - Low Impact

Fig. 4 Project impact area example.

MDT Tools and Output for Calculating Project Impact Area and Magnitude

Although both MDT versions use the same methods for creating the project impact area and magnitude, the MDT-Desktop has a specific tool for creating these data, the *Step 2 - Calculate Project Impact Area* where as the MDT-Web combines this process within the offset analysis to increase efficiencies in data processing and web data transfer. Output from either produces a raster dataset with three unique values of 30, 20, and 10 which is then used in the offset compensation calculation analysis.

Step 3 – Calculate Offset Compensation and Potential Locations

The final step of the MOG is to calculate the offset compensation required to comply with the regulation and offset the project impacts. Additionally determining where to offset becomes an important consideration when directing compensation. Within the MOG, steps have been identified to calculate offset compensation and are followed by the MDT. With regards to identifying where to offset, no guidance is provided by the MOG. TNC therefore created its own methodology for identifying potential offset locations which is described here. It is important to note this is just one methodology for locating offsets and not necessarily the definitive one.

Offset Compensation

To calculate the required amount of compensation necessary to meet the MOG, the cumulative impact area and magnitude zones need to be compared spatially with the four locational offset factors; Ecosystem Category, Landscape Condition, Habitat Type, and Landscape Priority. Additionally the duration of impacts are factored into the compensation based on placing all impacts into one of three temporal categories (i.e. short-term, medium, and long-term). These five factors are then used to derive a final offset compensation value by using the assigned offset ratio matrix based on which impact magnitude zone falls within which of three categories associated with each factor.

Locational Offset Factors

The locational offset factors are four spatially explicit datasets derived from national and ERA specific data which divide the Mongolian landscape into three categories of biodiversity importance. These categories while named differently for each factor have the same offset ratio requirements when calculating compensation; i.e. the highest category requires a 3 to 1 offset, the medium category requires 1.5 to 1, and finally the low category requires a 0.2 to 1. For example if impacts occur within the highest category one hectare of impact would require 3 hectares of offset. Each locational factor is developed by a process identified within the MOG. Below is a brief description of this process with more details being available in *Appendix A: GIS Steps for Calculating Locational Offset Factors*.

Ecosystem Category

This factor classifies ecosystems into three categories; Unique Rare, or Common with Unique being the highest offset cost. The classification is based on a combination of ecosystem function and rarity as determined by expert opinion for each of the three ERA regions (i.e. Gobi, Grasslands, and West-Central). In general, the unique category has been assigned to any land features having water at or near the surface while the rare category are all forested lands. All other classifications with a few exceptions (i.e. cinder cones, desert sairs, and wet barren salt pans) were placed into the common category.

Landscape Condition

This factor classifies a region into three categories of cumulative human disturbance based on a Mongolia-wide Disturbance Index; Good, Moderate, and Poor with Good being the most costly to offset. The least disturbed 50% of the landscape is classified as Good; the most disturbed 5% of the landscape is classified as Poor; and the remaining area is classified as Moderate (i.e. 50%-95%).

Habitat Type

This factor classifies a region into three categories; Critical, Natural or Modified with Critical being the most costly to offset. This dataset is derived from three datasets: National Protected Areas, Proposed National Protected Areas, and the Mongolia-wide Disturbance Index. Areas within either the National Protected Areas or Proposed National Protected Areas are categorized as critical habitat. The most disturbed 5% of the landscape, based on the Mongolia-wide Disturbance Index, is classified as modified habitat. All other areas are classified as natural habitat.

Landscape Priority

This factor classifies Mongolia into three categories; High, Medium, or Low and is based on proximity to either the national protected areas (NPAs) or the proposed national protected areas (PNPAs). The high category which is the highest to offset is associated with any lands currently protected at the national lever or being proposed to be

protected at this level. All lands found within 20km of the high category are placed in the medium category. Finally, the low category is the remaining area more than 20km from the NPAs or PNPAs.

Methods for Calculating Offset Compensation

Both applications (i.e. MDT-Desktop and MDT-Web) calculate the offset compensation using the same process. This five step process is listed below with each step referencing Table 4 to further explain these steps.

Step 1 – Calculate the hectares for each locational offset factor impacted. This requires each of the four locational offset factors be intersected by the three magnitude zones of the cumulative impact area. Due to each offset factor having three categories, this process potentially produces nine possible combinations for which the total hectares found in each needs to be calculated (Table4-A, -B, -C and –D).

Step 2 – Assign duration of impacts. The duration of impact is defined by the user as either: permanent or long-term (operation for more than 20 years), medium duration (operation for 5 to 20 years), and limited duration (operation for less than 5 years). The duration is based on how long the project will operate and not the duration of each disturbance feature resulting from the project (e.g. mine pits and tailing piles). Once duration is selected, the hectares associated with the three impact magnitude zones are placed under that duration category (Table 4-E)

Step 3 – Summarize total hectares. All five tables are now summed for each possible combination producing the total hectares associated with each of the potential nine categories.

Step 4 – Calculate offset units. Using the overall offset ratios created by multiplying the cumulative impact zone ratios by the offset factor ratios (Table 4-G), each categories' summed hectares (derived in Step 3) is multiplied by the associated ratio to produce an offset unit value for each of the nine possible combination (Table 4-H).

Step 5 – Calculate offset costs per year. Finally the total offset units required by the MOG are calculated by summing all the offset units derived in Step 4. This value is then multiplied by the $5/offset unit cost to produce the yearly offset costs associated with this impact.

Table 4. Calculation of offset costs for a hypothetical development project. The cumulative impact area is 100 ha with the three zones of magnitude: high - 50 ha, medium - 10 ha, and low- 40 ha. The project life is estimated at 14 years. Tables A – E shows cross-tabulate area derived from the intersection of impact zones and the locational and temporal offset factors. Section F contains the total hectares of all offset factors (i.e. sum of Sections A- E). Section G lists the offset multipliers defined by the offset regulation. Section H contains the offset units = F x G. Table I is the final offset cost = total offset units multiplied by the cost per offset unit.

A) *Impact Area / Ecosystem Category*	Unique	Rare	Common
high impact	20	10	20
medium impact	2	4	4
low impact	10	20	10

B) *Impact Area / Landscape Condition*	Good	Moderate	Poor
high impact	5	15	30
medium impact	1	3	6
low impact	10	15	15

C) *Impact Area / Habitat Type*	Critical	Natural	Modified
high impact	15	15	20
medium impact	5	5	0
low impact	15	5	20

D) *Impact Area / Landscape Priority*	High	Medium	Low
high impact	10	20	20
medium impact	5	2	3
low impact	10	15	25

E) *Impact Area / Duration of Operation*	Long	Medium	Short
high impact	0	50	0
medium impact	0	10	0
low impact	0	40	0

F) *Total Hectares (A + B+ C + D + E)*	High	Medium	Low
high impact	50	110	90
medium impact	13	24	13
low impact	45	95	70

G) *Offset Multipliers*	High (3)	Medium (1.5)	Low (0.2)
high impact (1)	3	1.5	0.2
medium impact (0.66)	1.98	0.99	0.132
low impact (0.33)	0.99	0.495	0.066

H) *Offset Units (F x G)*	High	Medium	Low
high impact	150	165	18
medium impact	25.74	23.76	1.716
low impact	44.55	47.025	4.62

I) Total Offset Costs

Total Offset Units:	480.411
Offset cost per Unit:	$5
Total Offset Costs:	$2,402

Potential Offset Locations

Both MDT applications not only calculate offset compensation but also provide a method for identifying potential offset locations for which these funds could be allocated towards. These locations will always be a subset of either the NPAs or PNPAs. The selection of potential offset locations is done by matching the type and area of ecosystems impacted by the project (i.e. all lands within the project impact area) with those NPAs or PNPAs which have the same

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ecosystems and at minimum the same hectares of ecosystems within them. This selection process is done at three levels based on where the impacts occur. First all impacts occurring within an ERA (i.e. Gobi, Grasslands, West-Central) are matched with any NPAs or PNPAs found within that particular ERA boundary. Next impacts occurring within an Aimag are matched with only those NPAs or PNPAs found in that particular Aimag. Finally impacts occurring within a Soum are matched with only those NPAs or PNPAs found within that particular Soum. Although several potential offset locations at three geographic levels can be identified by the MDT, it is TNC's recommendation that priority for offsetting be directed toward c those locations closest to the impacted area.

Methods for Calculating the Potential Offset Locations

In order to efficiently make the offset selections, both applications (i.e. MDT-Desktop and MDT-Web) rely on three derived datasets having the necessary summarized ecosystem hectares from which to match the ecosystems impacted. Initially a dataset containing both the NPAs and PNPAs within each of the three ERAs is intersected with ecosystems dataset produced for that particular ERA and the hectares of each ecosystem found in the NPAs and PNPAs are calculated (Fig. 5). This dataset would then be used for selecting potential impacts at the ERA level. This same process is then done with the NPAs and PNPAs however these areas are further divided by both the Aimag and Soum boundaries with these intersecting areas having the ecosystems summarized and used in the selection process (Fig. 6 & 7).

Fig. 5. Summarizing ecosystems at the Gobi ERA-level for all National Protected Areas and Proposed Protected Areas.

Aimag-level Ecosystems Summaries

NAME	Govi-Altai	NAME	Bayanxongor		
HA_11	166769.789329	HA_11	59438.161894	■	11 barren
HA_12	733140.883593	HA_12	319396.529524	■	12 extreme arid
HA_13	990444.558952	HA_13	482412.394142	▨	13 true desert
HA_30	1058285.87825	HA_30	441851.023309	▢	30 semi desert
HA_40	67751.910976	HA_40	47599.520376	▨	40 desert steppe
HA_50	0	HA_50	0	■	50 dry steppe
HA_51	162067.279076	HA_51	60048.098111	■	51 wet depressions, small basins 100-1,000 km2
HA_52	30542.739795	HA_52	3480.188276	■	52 wet depressions, large basins > 1,000 km2
HA_60	340.486483	HA_60	310.47958	▨	60 mountain steppe
HA_70	268.224963	HA_70	1813.274236	■	70 moutains, rough terrain
HA_88	346.61034	HA_88	0	■	88 ephemeral lakes
HA_91	2245.006197	HA_91	1780.817791	■	91 seeps dense vegetation
HA_92	382.7411	HA_92	530.938454	■	92 riparian dense vegetation
HA_94	0	HA_94	0	■	94 mountain valleys
HA_95	0	HA_95	0	▨	95 sand massives

Fig. 6 Ecosystem Summaries at Aimag Level

Soum-level Ecosystems Summaries

NAME	Altai	NAME	Cogt	NAME	Erdene	NAME	Bayan-O'ndor	NAME	Shinejinst
HA_11	18611.628027	HA_11	18367.286109	HA_11	129790.875194	HA_11	52756.420863	HA_11	6681.741031
HA_12	209546.159457	HA_12	153943.36958	HA_12	369651.354557	HA_12	223779.229298	HA_12	95617.300226
HA_13	276649.553912	HA_13	266607.652215	HA_13	447187.352825	HA_13	275655.651824	HA_13	206756.742319
HA_30	232697.403125	HA_30	311984.824667	HA_30	513603.650457	HA_30	237751.422804	HA_30	204099.600505
HA_40	22399.84634	HA_40	17990.05648	HA_40	27362.008156	HA_40	12310.790939	HA_40	35288.729437
HA_50	0	HA_50	0	HA_50	0	HA_50	0	HA_50	0
HA_51	42590.817243	HA_51	49358.904665	HA_51	70117.557168	HA_51	39759.757873	HA_51	20288.340239
HA_52	9926.160789	HA_52	6400.043581	HA_52	14216.535425	HA_52	3352.812038	HA_52	127.376238
HA_60	0	HA_60	340.486483	HA_60	0	HA_60	306.805266	HA_60	3.674315
HA_70	0	HA_70	268.224963	HA_70	0	HA_70	97.369336	HA_70	1715.9049
HA_88	0	HA_88	0	HA_88	346.61034	HA_88	0	HA_88	0
HA_91	405.399373	HA_91	417.647089	HA_91	1421.959735	HA_91	985.328688	HA_91	795.489103
HA_92	75.935834	HA_92	206.374001	HA_92	100.431265	HA_92	355.796127	HA_92	175.142327
HA_94	0	HA_94	0	HA_94	0	HA_94	0	HA_94	0
HA_95	0	HA_95	0	HA_95	0	HA_95	0	HA_95	0

Fig. 7 Ecosystem Summaries at the Soum Level

MDT Tools and Output for Calculating Offset Compensation and Potential Locations

The MDT-Desktop separates the offset compensation and location identification into two separate tools, *Step 3 – Calculate Offset Cost Report* and *Step 4 (optional) – Identify Potential Offset Sites*. By comparison, the MDT-Web application runs both of these processes and creates the project impact area within one tool, the *Offset Analysis* tool. While the MDT-Desktop returns both the offset cost report and the potential offset site locations directly to the user, the MDT-Web relies on emailing output to the user once all processes are completed on the TNC server hosting the application. Regardless of the application used, each will return the same formatted output with an html offset compensation cost report and shapefiles identifying the potential offset location. Due to generalization techniques required to pass data to the web server, the cost reports produced for the same LDs may have very slight differences.

MDT Offset Cost Report

The MDT Offset Cost Report is an html document with two main headings; Offset Costs and Land Disturbance Impacts (Figs. 8-10). The user can jump to each category by clicking on the headings under the title of report. The Offset Cost section identifies the total offset costs required by following the MOG and breaks these costs down according to each offset factor (Figs. 8-9). The *Disturbance Impacts* section of the MDT Cost Report (Fig. 10) identifies the impact area dataset used for the report and the cumulative hectares for each impact category. Additionally this section identifies what percentage of the impacts occurs within each Soum and identifies the

ecosystems impacted within each Soum. Due to the ecosystems data originating from three ERAs, the name of the ERA associated with the impacted ecosystems is also listed in the heading.

The *Offset Costs* section of the MDT report (Figs. 8 - 9) totals the offset units required for the project impact area, lists the cost per unit for offsetting (i.e. $5/unit), and totals the final per year offset costs. Additionally it details how the total offset units are derived by providing tables for each offset factor used in the calculation (i.e. ecosystem category, habitat type, landscape condition, landscape position, and project duration).   Each offset factor table identifies the impact category on the left and the offset factor category at the top. In parenthesis is the associated ratio required for each impact and factor category. For each possible combination of impact and offset factor category (e.g. High/Unique, High/Rare, High/Common, etc.), the amount of actual hectares is calculated and placed in the column *Actual (ha)*. An offset unit value is then calculated based on the ratios associated for each combination and the actual hectares. This offset unit value is then placed in the column *Offset Units*. For example using Fig. 8, the combination category of High/Unique under the Ecosystem Category table has identified 539.36 hectares. To obtain the offset units required for this combination, 539.36 hectares would be multiplied by 1 since that is the *High* category for the Impact Area and then by 3 since this is the *Unique* category for the Ecosystem Category factor thus equaling 1,686 offset units (i.e. 1*3*539.36 = 1618.08, rounded to 1,618 offset units). The offset units for all nine possible combinations are summed together and totaled at the bottom of each factor table. Since the user pre-selects one of the three possible project duration factors, the Project Duration table (bottom of Fig. 9) has only three possible combinations for which the offsets units are summed. The total offset units are then calculated by summing the totals for each of the five offset factors. This total offset unit value is multiplied by the offset unit cost (i.e. $5/offset unit) to derive the final yearly offset cost total.

MDT Offset Report for Oakleaf Mine

Quick Page Links: Offset Costs   Land Disturbance Impacts

Offset Costs

Total offset units required based on ratios = 16,805
Offset cost rate = $5/unit
Total offset costs per year for land disturbances = $84,025

Cost Details

Ecosytem Category

	Ecosytem Category					
	Unique (3)		Rare (1.5)		Common (0.2)	
Impact Category	Actual (ha)	Offset Units	Actual (ha)	Offset Units	Actual (ha)	Offset Units
High (1)	539.36	1,618	644.24	966	517.55	104
Medium (0.66)	9.36	19	50.58	50	47.18	6
Low (0.33)	100.56	100	594.29	294	587.08	39
Total offset units = 3,196						

Habitat Type

	Habitat Type					
	Critical (3)		Natural (1.5)		Modified (0.2)	
Impact Category	Actual (ha)	Offset Units	Actual (ha)	Offset Units	Actual (ha)	Offset Units
High (1)	0	0	1,701.15	2,552	0	0
Medium (0.66)	0	0	107.12	106	0	0
Low (0.33)	0	0	1,281.93	635	0	0
Total offset units = 3,293						

Fig. 8 MDT Offset Cost Report Example – Offset Cost section

MDT Offset Report for Oakleaf Mine

Landscape Condition

Impact Category	Landscape Condition					
	Good (3)		Moderate (1.5)		Poor (0.2)	
	Actual (ha)	Offset Units	Actual (ha)	Offset Units	Actual (ha)	Offset Units
High (1)	1,701.15	5,103	0	0	0	0
Medium (0.66)	107.12	212	0	0	0	0
Low (0.33)	1,281.93	1,269	0	0	0	0
Total offset units = 6,584						

Landscape Priority

Impact Category	Landscape Priority					
	High (3)		Medium (1.5)		Low (0.2)	
	Actual (ha)	Offset Units	Actual (ha)	Offset Units	Actual (ha)	Offset Units
High (1)	0	0	0	0	1,701.15	340
Medium (0.66)	0	0	0	0	107.12	14
Low (0.33)	0	0	0	0	1,281.93	85
Total offset units = 439						

Project Duration

Impact Category	Project Duration	
	Medium (1.5)	
	Actual (ha)	Offset Units
High (1)	1,701.15	2,552
Medium (0.66)	107.12	106
Low (0.33)	1,281.93	635
Total offset units = 3,293		

Fig. 9 MDT Offset Cost Report Example – Offset Cost section (continued)

Land Disturbance Impacts

Data associated with impacted area: *XSoumsFencedDisturb*
File location: *D:\Data\Applications\JRO_Tools\MDT\app_old_versions\Old_Data\final_tests\impacts_output.gdb\XSoumsFencedDisturb*

- 100% of impacts within the Gobi ERA
- 33.65% of impacts found within Ulaanbadrax Soum in Dornogovi Aimag.
- 66.35% of impacts found within Xo'vsgol Soum in Dornogovi Aimag.

Impact Area

Impact Category	Hectares
High	1,701.15
Medium	107.12
Low	1,281.93
Total impacted: 3,090.2 ha	

Gobi Ecosystems (ES) Impacted within Ulaanbadrax Soum

ES Code	ES Category	Hectares Impacted
51	wet depressions, small basins 100-1,000 km2	192.45
92	riparian dense vegetation	102.1
95	sand massives	745.36

Gobi Ecosystems (ES) Impacted within Xo'vsgol Soum

ES Code	ES Category	Hectares Impacted
40	desert steppe	817.4
50	dry steppe	327.31
51	wet depressions, small basins 100-1,000 km2	344.29
92	riparian dense vegetation	12.2
95	sand massives	549.09

Fig. 10 MDT Offset Cost Report Example – Land Disturbance Impacts section

MDT Potential Offset Sites

Both applications generate spatial datasets in the ESRI shapefile format identifying potential offset sites at three levels (i.e. ERA, Aimag, and Soum). For example in Fig. 11, there is a shapefile identifying offset sites at the Gobi ERA level , the Dornogovi Aimag level, and the Ulaanbadrax Soum level. These shapefiles follow the naming convention of *OffSites_In_<ERA Name>_ERA*, *OffSites4_<Aimag Name>_in<ERA Name>*, and *OffSites4_<Soum Name>_in<ERA Name>*. If there are no matching offset sites found within any of these levels, then that particular level is not created.

Each potential offset dataset will have protection status of the site in the Category field with values indicating whether the site is a National Protected Area or Proposed NPA.   Additionally each dataset will have the name of the site (i.e. Name field) and the shortest straight-line distance from portfolio site boundary to impacted area boundary area (i.e. dist_away field). Finally for the Aimag and Soum potential offset sites, name of each will be located with the attribute table too.
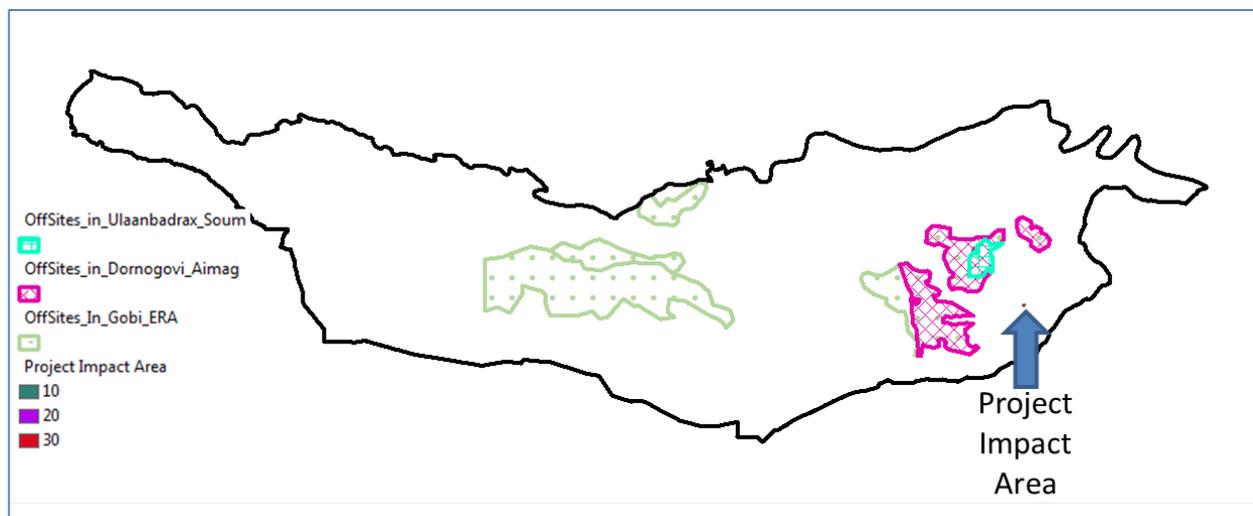
Fig. 11 Example shapefiles for three levels of potential offset sites.

Avoidance Analysis

Critical before companies move into offsetting impacts is the need for them to first look at ways to avoid or minimize the impacts prior and during development. Both the MDT-Desktop and MDT-Web provide users with the ability to examine data to potentially limit their offset costs while also avoiding important and legally-limiting landscapes.

Avoidance Data – Cumulative Offset Factor and Development Restrictions

The MDT applications use six datasets to identify those lands which by law are restricted to mining; national protected areas (NPAs), local special protected areas (LSPAs), headwater areas (HAs), forested areas (FAs), and riparian/wetland areas (RAs).   Restrictions or complete avoidance may be needed for developing in or near these areas and thus identifying potential conflict within these areas prior to development allows for companies to mitigate these issues before investing heavily in the proposed development. Both the NPAs and LSPAs are updated within the applications on a yearly basis to reflect any changes occurring across Mongolia. The HAs, FAs, and RAs were produced by Mongolia WWF and MEGD to represent areas identified by Mongolia law prohibiting the exploration and exploitation of minerals within headwater areas, protected zones of water fund and forest fund and rehabilitation of these areas. For more information on how these data were created contacted Mongolia WWF or MEGD.

To help companies lower potential offset costs associated with planned LDs, the cumulative offset factors (COF) dataset was created. COF is a raster dataset having values based on summing offset ratios of all four locational offset factors (described above) which produces cell values ranging from 0.8 - cells which all four factors identify as least important and therefore will require the lowest compensation, to 12.0 - cells which all four factors consider very important and thus require the highest compensation.   Although these are just relative offset ratio values, they do indicate directly where impacts will ultimately be most costly to offset and thus give guidance for avoidance.

MDT - Avoidance Tools and Output

Both the MDT-Desktop and MDT Web gives users the ability to assess all land disturbances used in the analysis. For the MDT-Desktop this is done with the *Compare Land Disturbances* tool while the MDT-Web uses the *Avoidance Analysis* tool. Both produce the same output ,a polygon feature class represented by buffering the inputted LDs. Buffer distances are based on the assigned maximum impact distance for each LD (see *Step 2 - Calculating Project Impact Area and Magnitude* section) with each polygon having the original attributes of the feature being buffered and ten new fields: *buff_dist*, *LinkID*, *mdt_avgCat*, *mdt_avg*, *mdt_TCRank*, *mdt_sum*, *mdt_PAs, mdt_FAs, mdt_HAs, and mdt_RAs.* Table 5 describes how each field is created. The mdt_avgCat, mdt_avg, mdt_TCRank, mdt_sum fields provide a method to relatively compare the LDs among each other based on either average or total potential offset factor value. Again this value is more to provide guidance on comparing potential LD contribution to the total potential offset cost and does not indicate the actual final offset costs since this will be determined by the impact magnitude of the overall development (see *Step 3 – Calculate Offset Compensation and Potential Location* section).

Table 5. Field descriptions for fields produced when running avoidance analysis.

Field Name	Values	Description
buff_dist	Variable	Distance used for calculating impacts specific to that LD. Assigned based on Table 3 values found within the column Max Impact Distance associated with an LD
LinkID	Variable text	Identifies the disturbance feature the buffer area is derived from, for example P_0 would indicated this impact area was derived from the first area disturbance where as L_0 indicates that feature was derived from the first linear disturbance.
mdt_avgCat	High – mdt_avg > 8.3 Medium – mdt_avg > 4.5 and mdt_avg <=8.3 Low – mdt_avg < =4.5	Categorical description based on the average offset score within the LD buffered feature. Derived by categorizing the calculated mdt_avg field.
mdt_avg	12 (highest) - 0.08 (lowest)	The average, cumulative offset factor values created by calculating the average of all cell values within the LD buffered feature.
mdt_TCRank	ordinal rank 1 (lease with highest total cost)	The ordinal ranking of the calculated mdt_sum field.
mdt_sum	Variable	The total, cumulative offset factor value created by calculating the sum of all cell values within the LD buffered feature.
mdt_PAs	0- No national or local special protected areas within buffered LD 1- Local special protected areas found within buffered LD 2- National protected areas found	Indicates LD buffer overlaps either a national protected areas or a local special protected area .

	within buffered LD 3-Both local and national protected area found within buffered LD	
mdt_FAs	0- No forested areas located within impact. 1-Forested areas located within impact.	Indicates LD buffer overlaps with forested areas.
mdt_HAs	0- No headwater areas located within impact. 1-Headwater areas located within impact.	Indicates LD buffer overlaps with headwater areas.
mdt_RAs	0- No riparian or wet areas located within impact. 1- Riparian or wet areas located within impact.	Indicates LD buffer overlaps with riparian or wet areas.

The MDT-Desktop also provides an additional avoidance tool which allows users to compare potential mineral leases. This can be done by using the *Compare Leases* tool. The user selects a polygon feature class representing the leases to compare and selects an output for the analysis. Similar to the how the MDT calculates the LD avoidance data, eight new fields are included within the new outputted feature class: *mdt_avgCat*, *mdt_avg*, *mdt_TCRank*, *mdt_sum*, and *mdt_PAs, mdt_FAs, mdt_HAs, and mdt_RAs.* These fields are calculated in the same methodology as the *Compare Land Disturbances* (see Table 5) but using lease boundaries instead of the buffered LDs. The actual offset costs will be determined by the location and types of disturbances found within the lease boundary.

Mongolia Offset Regulation – General GIS Steps

ArcGIS Steps with MDT-Desktop Tool

Step 1 (Option A) – Create Land Disturbance Data from other software
1. Convert disturbance data to shapefile format or create.
2. Project both your linear and area shapefiles so they are using the projected coordinate system - UTM, Zone 48N projection based on the WGS 1984 datum.
3. Create a code field which can hold integer values and assign these values based on the LD codes based on Table 1- Linear LD Types and Table 2 – Area LD Types)
4. Check data by running *Land Disturbance Data Check* tool. Output of tool will identify potential errors with data and possible restrictions to development based on disturbances.
5. Fix necessary errors.

Step 1(Option B) - Create Land Disturbance Data using ArcGIS
1. Run *Create Land Disturbance Data* tool.
2. Use created LD feature classes to digitize land disturbance.
3. Assign LD code using domains associated with LD_Code field created for each LD feature class.

Step 2 – Modify LDs to minimize offset costs and avoid development restrictions
1. Run *Compare Land Disturbances* tool
2. When possible edit LDs to avoid high cumulative offset factor values and restricted development areas.

Step 3 - Create Cumulative Impact Area and Magnitude dataset
      Run *Step 2 – Calculate Project Impacts* tool

Step 4 - Calculate Offset Report
      Run *Step 3 – Calculate Offset Report* tool

Step 5 –Identify Potential Offset Sites
      Run Step 4 – Identify Potential Offset Sites tool.

QGIS Steps with MDT–Web Tool

(For more details on using QGIS see *Appendix D – Tutorial for QGIS 2.12 Users*)

Step 1 – Create LD Data
1. Create LD features in shapefile format using QGIS digitizing tools.
2. Assign appropriate codes for each disturbance type (see Identify Planned Disturbance section of this document).

Step 2 – Place all files associated with LD shapefiles in a zip file.
      Create one zip file containing all files associated with the linear and area shapefile data.

Step 3 – Open MDT-Web application.
      Using your preferred web browser, open
      http://s3.amazonaws.com/DevByDesign-Web/MappingAppsVer2/MDT_Mongolia/index.html

Step 4 – Upload and test zip file within MDT - Web
1. Using the Upload Land Disturbances Data tool from the MDT Analysis menu, use the Browse button to upload your zip file.
2. Click on the Run LD Check button to check LD data uploaded.
3. Fix any attribution errors within MDT-Web by clicking on feature.
4. Re-run LD Check.
5. Repeat process until analysis reports data are error free.

Step 5 - Run the Offset Analysis tool
1. Input the three required fields:
   a. project life,
   b. project name,
   c. Email address.
2. Click on the Run Offset Analysis button.
3. The Internet application will run analysis to produce cumulative impact area, offset report, and potential offset sites. All data including the land disturbances data uploaded will be packaged within a zip file which is emailed to the user. Once user clicks on the Run Offset Analysis button, the analysis will run regardless if the user closes their web browser.

Step 6 – Uncompressed zip file and examine data in QGIS

Appendices A - F

Appendix A: GIS Steps for Calculating Locational Offset Factors

Ecosystem Category

Description:

This factor classifies ecosystems into three categories; Unique, Rare, or Common with Unique being the highest offset cost. The classification is based on a combination of ecosystem function and rarity as determined by expert opinion for each of the three ERA regions (i.e. Gobi, Grasslands, and West-Central). Originally this factor was based strictly on percent area of ecosystem found within a biogeographical region. This however did not account for the unique values (ecosystem services, habitat) of wetlands and many times artificially inflated rakings of ecosystems which were found on the edge of their range. The Table A1 below identifies the selected classifications for all ecosystems classified by ERAs in Mongolia:

Table A1. Summary of ecosystem types across Mongolia and the associated offset category assigned to this type for MDT Applications.

Ecosystem Type	Offset Category
desert dense veg	Unique
desert wet shrubs	Unique
dry river bed	Unique
endorheic lakes	Unique
endorheic wet areas	Unique
ephemeral lakes	Unique
floodplains	Unique
lakes	Unique
mountain valleys	Unique
riparian dense vegetation	Unique
riverine forest	Unique
riverine meadow	Unique
riverine shrub	Unique
seeps dense vegetation	Unique
small stream riparian	Unique
water	Unique
wet areas	Unique
wet depressions, large basins > 1,000 km2	Unique
wet depressions, small basins 100-1,000 km2	Unique
alpine meadow and subalpine woodland	Rare
cinder cones	Rare
desert sairs	Rare
desert wet barren salt pan	Rare
forest closed	Rare
forest open	Rare
forest steppe	Rare
high mountain deciduous-coniferous woodland	Rare
mountainous boreal coniferous forest	Rare
sub-boreal coniferous-deciduous forest	Rare
Agland	Common
alpine – barren	Common
alpine – tundra	Common
alpine steppe	Common
Barren	Common

desert steppe	Common
dry and moderately steppe	Common
dry steppe	Common
extreme arid	Common
high mountain meadow	Common
high mountain steppe	Common
high mountain tundra	Common
lower mountain steppe	Common
meadow	Common
meadow steppe	Common
moderate dry steppe	Common
mountain steppe	Common
mountains - rough terrain	Common
sand massives	Common
semi desert	Common
true desert	Common

Input Data Required:
- Ecosystem Classification – EC

Creation Steps:
1. Select appropriate values and assign categories
2. Reclassify ecosystem raster based on categories (i.e. Unique – 3, Rare – 2, and Common -1)

Description of Final Categories:

3 (Unique) – Areas associated with water at or near the surface.

2 (Rare) – Mainly forested areas across Mongolia

1 (Common) – Remaining ecosystem types

Ecosystem Category for Mongolia:
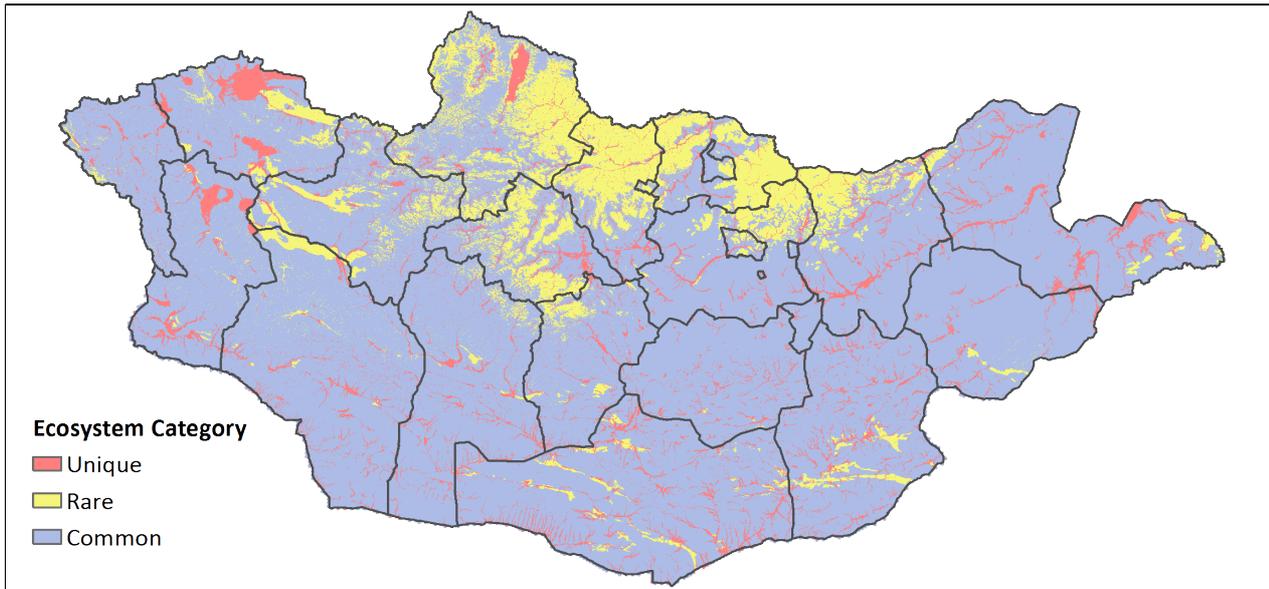
Landscape Condition

Description:

This factor classifies a region into three categories of cumulative human disturbance based on a Mongolia-wide Disturbance Index; Good, Moderate, and Poor with Good being the most costly to offset. The least disturbed 50% of the landscape is classified as Good; the most disturbed 5% of the landscape is classified as Poor; and the remaining area is classified as Moderate (i.e. 50%-95%).

Input Data Required:

- Disturbance Index (DI)

Creation Steps:

1. Slice DI into 100 zones using Equal Area
2. Reclassify slice data into the following categories:
   - 1 : >= 95 (i.e. low)
   - 2 : 50-94 (i.e. medium)
   - 3 :   <50 (i.e. good)

Description of Final Categories:

3 (Good) - least disturbed 50% of the landscape (i.e. <50 percentile of the disturbance index)

2 (Moderate) – The 45% of cells having disturbance values above *Good* and below *Low* (i.e. 50 – 94 percentile of the disturbance index)

1 (Poor)- the most disturbed 5% of the landscape (i.e. > 95 percentile of the disturbance index)

Landscape Condition for Mongolia:
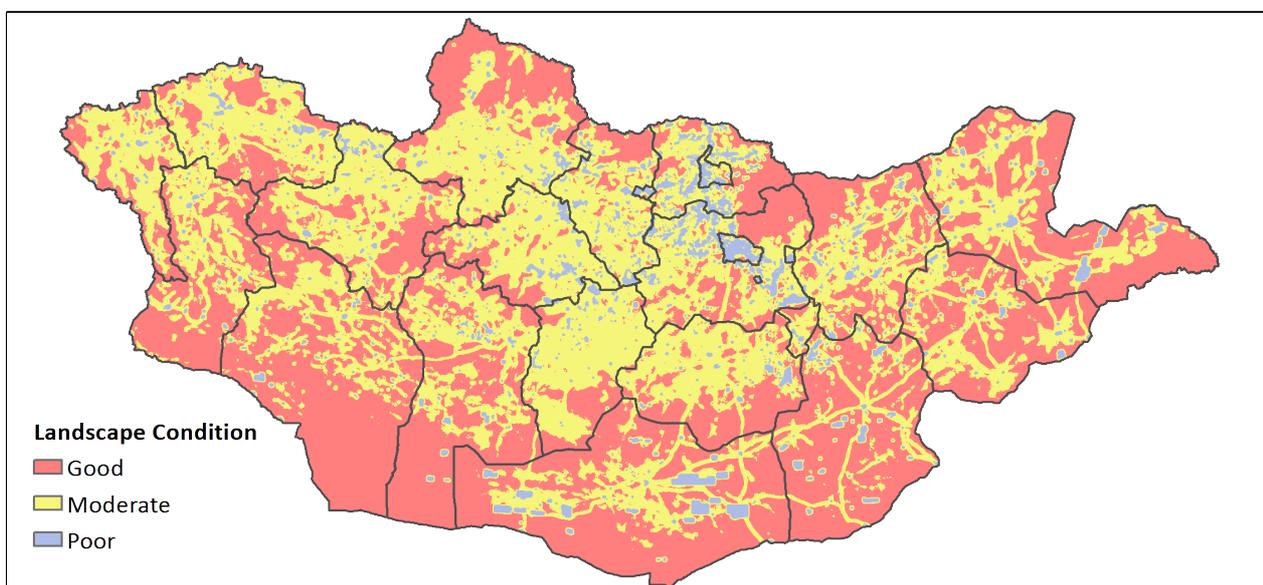
Habitat Type

Description:

This factor classifies a region into three categories; Critical, Natural or Modified with Critical being the most costly to offset. The map is created by using three datasets: National Protected Areas, Proposed National Protected Areas, and the Mongolia-wide Disturbance Index. Areas within either the National Protected Areas or Proposed National Protected Areas are categorized as Critical habitat. The most disturbed 5% of the landscape, based on the Mongolia-wide Disturbance Index, is classified as Modified habitat. All other areas are classified as Natural habitat.

Input Data Required:

- National Protected Areas (NPA)
- Proposed National Protected Areas(PNPA)
- Landscape Condition (LC) – previously created

Creation Steps:

1. Combine NPAs and PNPAs into one dataset
2. Within combined layer (Step 1) create field for grid conversion and calculate field to the value of 3
3. Convert to a raster dataset using grid field calculated in Step 2
4. Using LC select out values of 1 (low site condition) and calculate all others to 2
5. Combine Step 3 with Step 4 keeping the maximum value. Create s Habitat Type Raster with 3 - Critical, 2 – Natural, 1 - Modified

Description of Final Categories:

3 (Critical) – Lands identified as a National Protected Area or Proposed Protected Area.

2 (Natural) – Any area not identified as either critical or modified

1 (Modified)- The most disturbed 5% of the landscape, based on the Mongolia-wide Disturbance Index

Habitat Type for Mongolia:
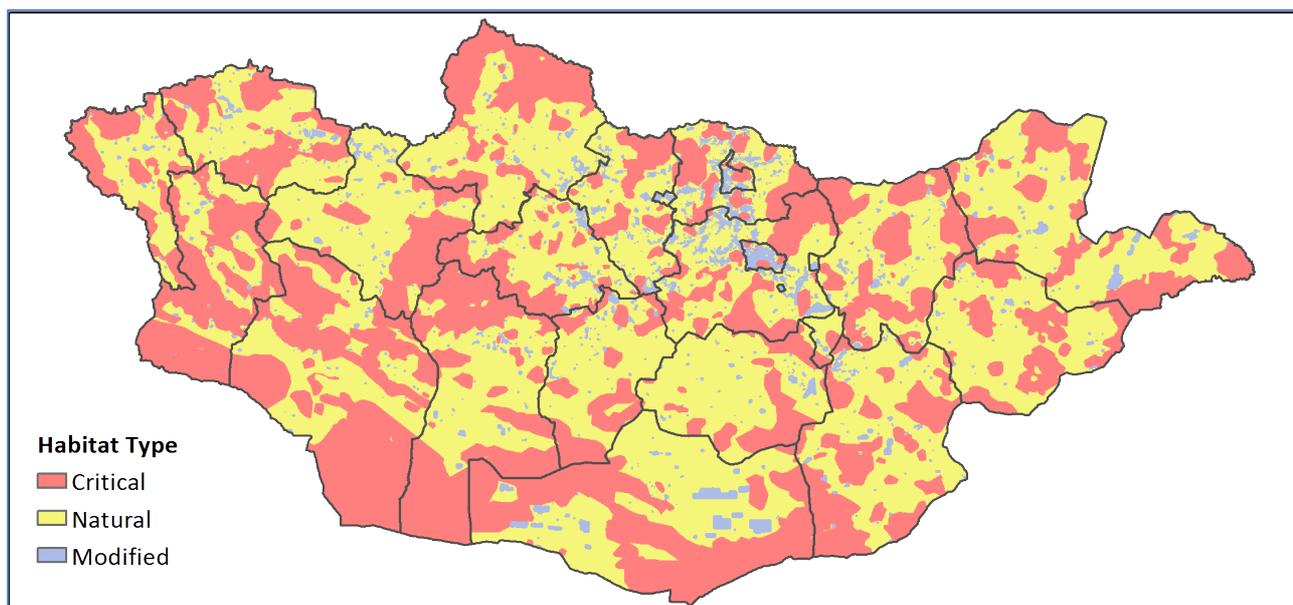
Landscape Priority

Description:

This factor classifies a region into three categories; High, Medium, or Low and are based on proximity to either the National Protected Areas or the Proposed Protected Areas. The High category contains all Proposed and currently National Protected Areas and are the most costly to offset. The Medium category is the area within 20km of the High category. The Low category is the remaining area more than 20km from the High category.

Input Data Required:

• Habitat Type (HT) – previously created

Creation Steps:

1. Select only HT values = 3 (i.e. Critical category)
2. Buffer Step 1 by 20km and assign the buffer area as 2
3. Calculate all areas outside of 20km and not within critical areas as 1
4. Combine Steps 1-3 keeping the maximum value. Creates Landscape Priority raster with 3 =High, 2 – Medium, 1 - Low

Description of Final Categories:

3 (High) – Lands within either the National Protected Areas or the Proposed Protected Areas.

2 (Medium) – Lands within 20km any High category.

1 (Low) - All other lands

Landscape Priority for Mongolia:
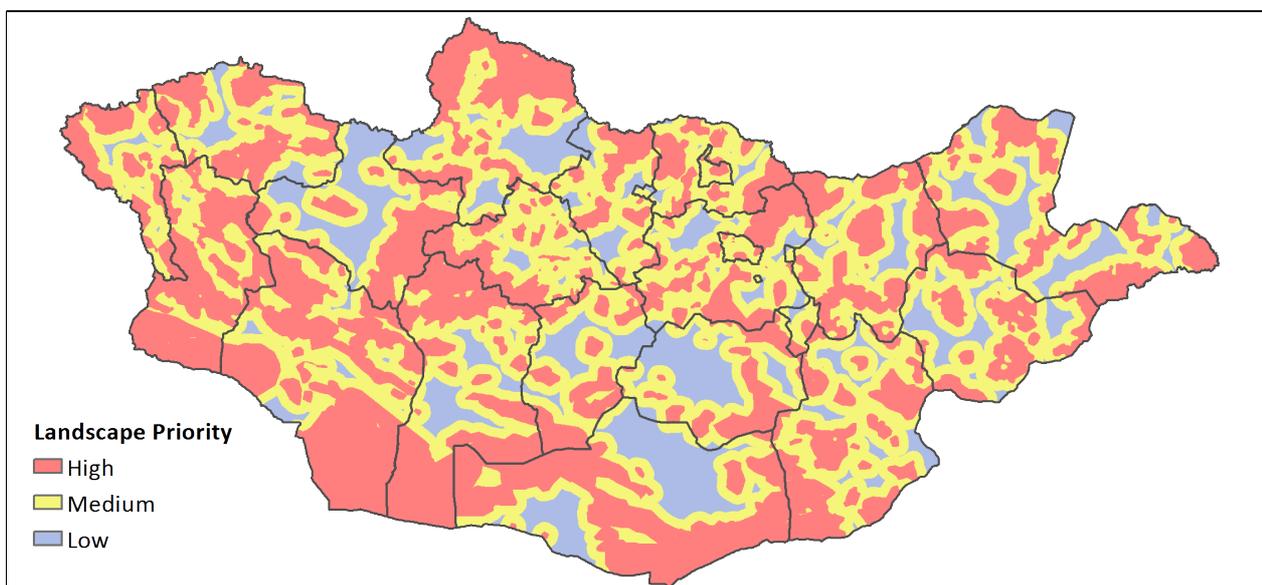
Appendix B –MDT Spatial Database

The MDT applications rely on a collection of spatial data to accurately calculate offset compensation and potential offset areas (Table B1).

Table B1. Spatial Data Required by MDT applications

Name	*Description*
Avoidance Datasets	**Data used for development avoidance and reduction of offset costs.**
COF.img	The cumulative offset factors raster dataset with values produced by summing all four locational offset factors together
Forest_Areas.shp	These data display the forested areas across Mongolia. According to Mongolia law the exploration and exploitation of minerals is prohibited within these areas.
Headwater.shp	These data display the headwater areas across Mongolia. According to Mongolia law the exploration and exploitation of minerals is prohibited within these areas.
PA_Local.shp	Local special protected areas for all Mongolia as of Sept. 2015.
PA_National.shp	National protected areas for all of Mongolia as of Sept 2015.
Riparian.lyr	Layerfile displaying riparian and wet areas.
Riparian_Wet_Areas.shp	These data display the riparian areas across Mongolia. According to Mongolia law the exploration and exploitation of minerals is prohibited within these areas.
Locational Offset Factors	**Data used in calculating offset compensation requirements.**
EsCategory.img	Locational Offset Factor - Ecosystem Category raster dataset
HabitatType.img	Locational Offset Factor – Habitat Type raster dataset
LdCondition.img	Locational Offset Factor – Landscape Condition raster dataset
LdPriority.img	Locational Offset Factor – Landscape Priority raster dataset
LD Impact Values	**Tables used in deriving the project impact for LDs**
area_disturbances.dbf	Table containing necessary data to calculate impact zones for area disturbances (see Assigned LD Impact Parameters of GIS_PPC).
linear_disturbances.dbf	Table containing necessary data to calculate impact zones for linear disturbances (see Assigned LD Impact Parameters of GIS_PPC).
Potential Offset Locations	**Data used to identify potential offset locations associated with LD impacts**
Aimag_Bnd.img	Raster dataset identifying Aimags in Mongolia
Aimags_Polys.shp	Polygon feature class identifying Aimags in Mongolia
ERA_Bnd.img	Raster dataset identifying the three ERAs completed in Mongolia
ERA_Polys.shp	Polygon feature class identifying the three ERAs completed in Mongolia
Soum_Bnd.img	Raster dataset identifying Soums in Mongolia
Soums_Polys.shp	Polygon feature class identifying Soums in Mongolia and the associate Aimag the Soum is located in.
East_aimags_ports.shp	ERA portfolio sites intersected with Aimag boundaries. Attributes contain the HA of each ecosystem class found in that unit.
East_era_ports.shp	ERA portfolio sites. Attributes contain the HA of each ecosystem class found in site.
East_es.img	Raster dataset of ecosystems mapped by analysis done for ERA

East_es_lut.dbf	Table containing ecosystem codes and associate descriptions for types found in ERA.
East_soums_ports.shp	ERA portfolio sites intersected with Soum boundaries. Attributes contain the HA of each ecosystem class found in that unit.
Gobi_aimags_ports.shp	ERA portfolio sites intersected with Aimag boundaries. Attributes contain the HA of each ecosystem class found in that unit.
Gobi_era_ports.shp	ERA portfolio sites. Attributes contain the HA of each ecosystem class found in site.
Gobi_es.img	Raster dataset of ecosystems mapped by analysis done for ERA
Gobi_es_lut.dbf	Table containing ecosystem codes and associate descriptions for types found in ERA.
Gobi_soums_ports.shp	ERA portfolio sites intersected with Soum boundaries. Attributes contain the HA of each ecosystem class found in that unit.
West_aimags_ports.shp	ERA portfolio sites intersected with Aimag boundaries. Attributes contain the HA of each ecosystem class found in that unit.
West_era_ports.shp	ERA portfolio sites. Attributes contain the HA of each ecosystem class found in site.
West_es.img	Raster dataset of ecosystems mapped by analysis done for ERA
West_es_lut.dbf	Table containing ecosystem codes and associate descriptions for types found in ERA.
West_soums_ports.shp	ERA portfolio sites intersected with Soum boundaries. Attributes contain the HA of each ecosystem class found in that unit.

Updates or changes in any of these data or the data products which derive them must be reflected in the database to ensure the use of the application. TNC has agreed to update the database for one year prior to the end of the project however long-term this may not continue to be the case. In order to be consistent with updates and ease the required work with this effort TNC has created the MDT_Spatial_Database_Update_Tools (Fig. B1). This

Fig. B1 MDT Spatial Database Update Tools

ArcGIS toolbox has two tools for updating the database, the Update Offset Factor Database and the Update Potential Offset Locations. These tools are only shared with database managers of the MDT applications and require not only running the tools but also knowing where to place the data outputted from these tools with in either the MDT-Desktop or MDT-Web databases.
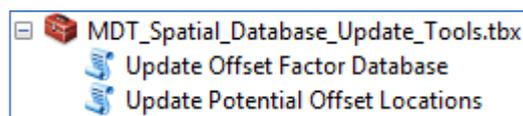
The Update Offset Factor Database tool (Fig. B2) allows for the user to quickly update the COF.img raster dataset and all four locational offset factors (i.e. ecosystem category, habitat type, landscape priority, and landscape position). Changes in the national disturbance index, national protected areas, proposed protected areas, or the terrestrial ecosystems data would make the use of this tool necessary. All data selected is expected to have an extent of all of Mongolia and use the projected coordinate system - UTM, Zone 48N projection based on the WGS 1984 datum. The terrestrial ecosystems data additionally requires the offset category value be assigned by attribute to all values contained in this raster dataset.

The Update Potential Offset Locations tool (Fig. B3) uses the polygon dataset containing the combined national and proposed protected areas to create spatial database
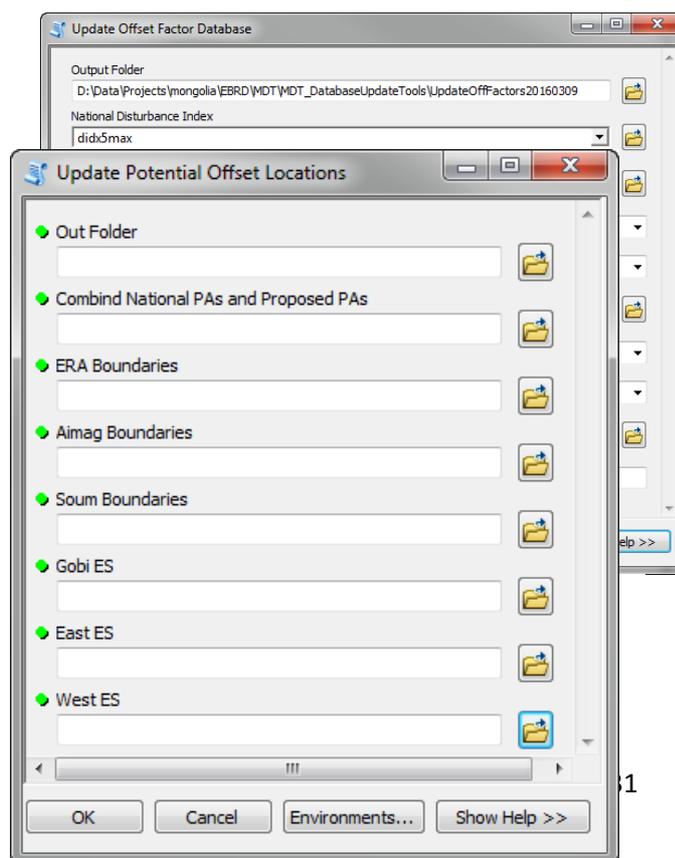
Fig. B3 Update Potential Offset Locations dialog.

identifying at each offset level (i.e. ERA, Aimag, Soum) the summary terrestrial ecosystems. The combined national protected and proposed protected data is an output from the Update Offset Factor Database tool previously discussed and therefore should be ran prior to running this tool. Any changes to the national or proposed protected areas or terrestrial ecosystems datasets at the ERA-level would require this tool be ran to update data.

Appendix C – Tutorial for ArcGIS 10x Users

Setup for Tutorial
☐ Make sure you have ArcGIS installed on your machine with Spatial Analyst extension installed.
☐ Download MDT-Desktop from http://s3.amazonaws.com/DevByDesign-Web/MonOffsetDesign/data.html and follow the installation procedures within the help documentation.
☐ Download MDT tutorial data from http://s3.amazonaws.com/DevByDesign-Web/MonOffsetDesign/data.html
☐ Un-package *mdt_tutorials.zip* in a read/write location on your computer (Hint: Answers for tutorial can be found in the *Solutions* folder within this zip file.
☐ Create an MDT_Output folder. This will be the folder for all data created in tutorial and be displayed within all dialogs as c:\MDT_Output.

Identifying Offset Costs and Potential Locations
☐ Open *Ex1.mxd* (i.e. File>Open menu) within the MDT_Tutorials folder.

☐ You will see three layers; Land Disturbances-Linear, Land Disturbances-Area and Fake Mine Plan. The Fake Mine Plan is a plan which was never developed however it has been geo-referenced to simulate a potential mining plan within the Gobi region.

☐ Using the measure tool ⟦measure icon⟧, what is the approximate area in KM^2 of this planned development?

☐ If you were going to digitize the land disturbances of this site plan with ArcMap, the first step would be to create land disturbances data using the ***Step1a – Create Land Disturbance Data*** tool. Open the ArcToolbox window and select the MDT toolbox and open this tool.

☐ Select your MDT_Output folder for a project Folder Location and keep the default setting for the rest of the tool.
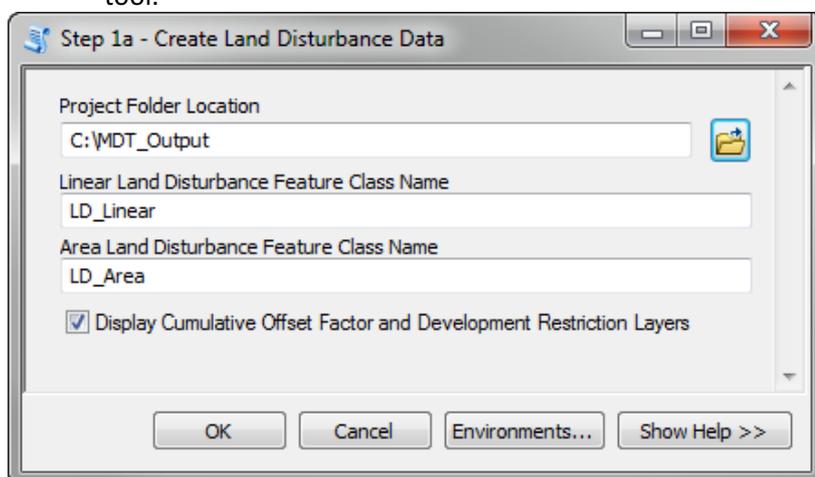
☐ Click the OK button.

☐ How many layers are added to ArcMap?

☐ Make visible all layers within the group layer Development Restriction Areas. Are there any mapped development restrictions in this area?

☐ The Cumulative Offset Factor layer gives users the ability to see estimate ratios for offset requirements while creating your land disturbance layers. This allows user when presented with options to choose lower offset

cost areas to develop. Place this layer below the Fake Mine Plan layer. Which land disturbance appears to have the potential for the highest offset cost?

☐ Remove all Development Restriction Area layers and Cumulative Offset Factor layer from ArcMap.

☐ Using the Catalog window, navigate to the MDT_Output folder, right click on mdt_land_disturbances.gdb and select the Properties menu. Click on the Domains tab in the Database Properties window. How many domains are associated with this file geodatabase?

☐ How many coded values are available for the MDT_LD_Area_Domain?

☐ Close the Database Properties window and display the layer properties associated with the LD_Area layer by right clicking on the layer name in the ArcMap Table of Contents and selecting the Properties menu. Click on the Fields tab within the Properties window and select the LD_Code field by clicking on its name in the list of field names. What is the name of the Coded value domain associated with this field?

☐ What field will therefor contain your land disturbance codes associated with the MDT?

☐ Now click on the Source tab within the Layer Properties window. What projection has been assigned to these data?

☐ Remove the LD_Linear and LD_Area layers. Normally you would use these datasets to begin digitizing land disturbances however they have already been digitized for you and are named Land Disturbances – Linear and Land Disturbances – Area.

☐ Now to check these datasets which have already been digitized, we will run the **Step 1b – Check Land Disturbance Data** tool. Open this tool within the MDT toolbox. Input the appropriate values within this dialog. It should look exactly like the dialog below.
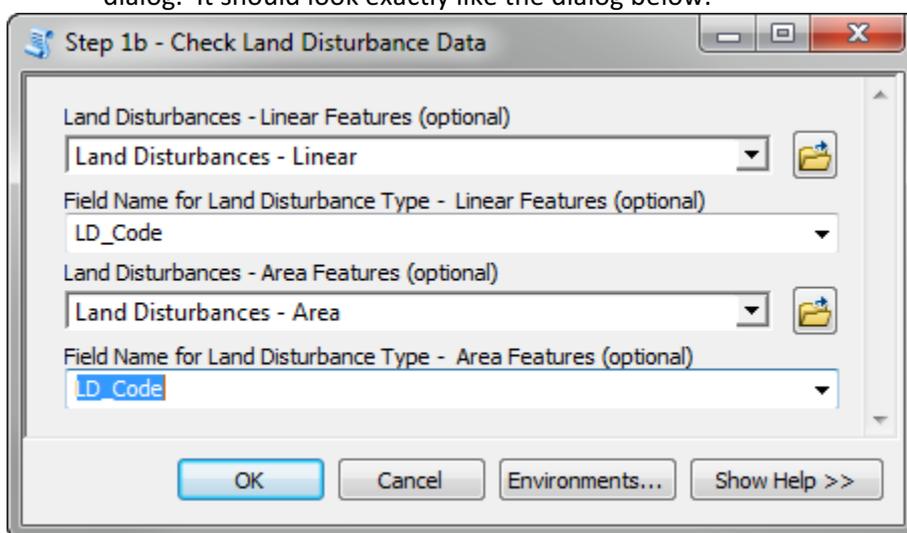
☐ How many errors were found within Land Disturbances – Linear layer?

☐ How many errors were found within Land Disturbances – Area layer?

☐ Basically none of the attributes have been assigned. We will now fix these errors by attributing features which caused the errors. Make the Land Disturbances – Linear layer the only visible layer.

☐ Start a new edit session. This can be done by clicking on the Editor button ✎ which displays the Editor Toolbar. Then by clicking on the Editor menu and selecting the Start Editing menu, you will start an edit session.

☐ Add the Attributes editing window by clicking on the Attributes button 🔲 on the Editor Toolbar.

☐ Now use the Editor Selection tool ▶ and select the main road running on the West and North side of the planned development. Within the LD_Code field click on the dropdown menu and select Roads-Paved.

☐ Assume the other linear features are Roads – Improved Dirt and code them following the same procedure as above.

☐ Save your edits by clicking on the Editor menu and selecting Save Edits. Clear all select features.

☐ Now make visible the Land Disturbances – Area and Fake Mine Plan layers. Follow the same procedures but this time select polygons and assign the appropriate land disturbance codes to these area features. If the Fake Mine Plan map is difficult to read, use the following guide:
Light blue – mine pit
Light brown – overburden piles
Dark green – growth media piles
Blue – heap leach pads
Dark brown – processing facilities except for the one nearest the entrance which is an office facility

☐ Save your edits, clear all selected features, and stop your edit session by clicking on the Editor menu and selecting Stop Editing.

☐ Now display each layer setting the symbology of each to use LD_Code field with a Unique Values categorization. Look at the screen capture below, your colors may be different but your ArcMap display should look similar with the layers overlapping all the land disturbances found in the georeferenced site plan. NOTE: Due to the Domain Codes associated with the LD_Code attributes, ArcMap automatically adds a legend with all possible domain codes. You will need to remove from the symbology those disturbances which are not part of this planned development.
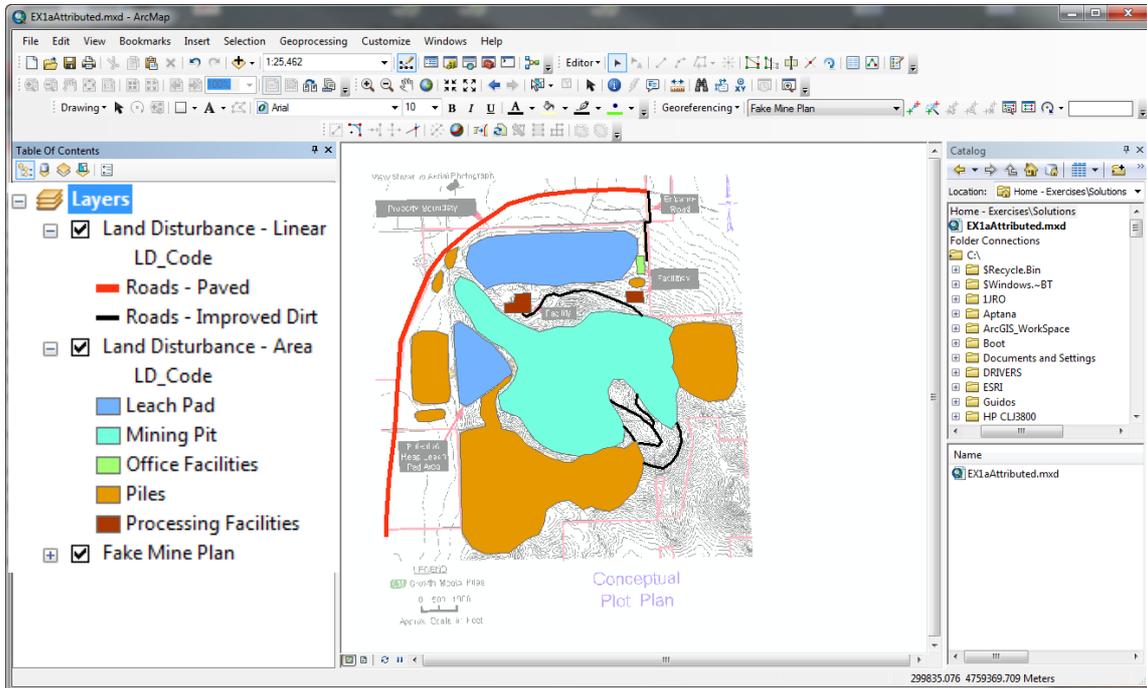
☐ If you missed one start a new edit session and attribute the feature you missed and save your edits.

☐ Now to double check our work, we will run the **Step 1b – Check Land Disturbance Data** tool. Open this tool within the MDT toolbox. Input the appropriate values within this dialog. It should look exactly like the dialog below.
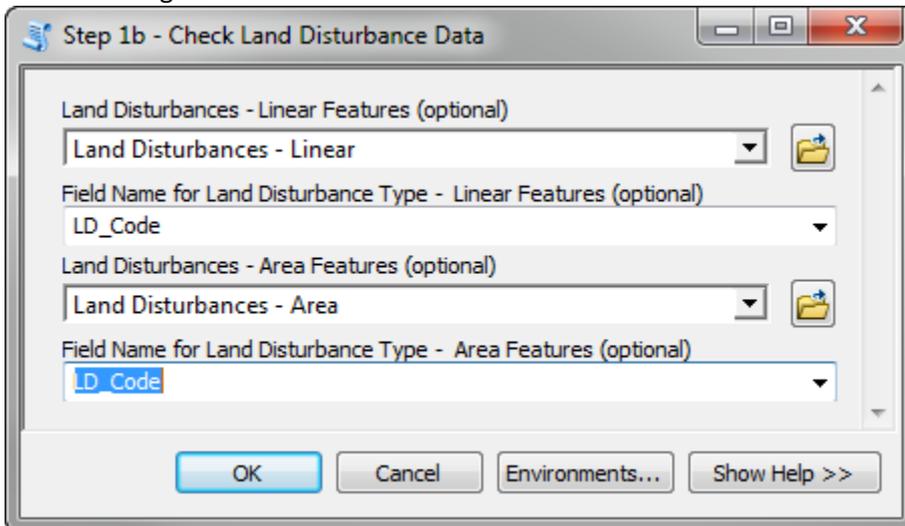
☐ You should have received a message saying: "There were no errors or warnings with your data. These data can be run successfully with the Step 2 – Calculate Project Impact tool."

☐ Open the **Step 2 – Calculate Project Impact Area** tool within ArcToolbox>MDT>Land Disturbance and Impact Tools. Set the Land Disturbance - Linear layer as the Land Disturbances – Linear Features and select the LD_Code field for the Field Name for Land Disturbance Type. Set the Area Features to the Land Disturbance - Area layer and select its LD_Code field for the Field Name. Finally name the Project Impact

Raster Dataset as Ex1ProjectImpact.img making sure to locate this output to your MDT_Output folder. Your dialog should look the same as the one below. NOTE: Make sure none of the land disturbance features are selected before running the tool.
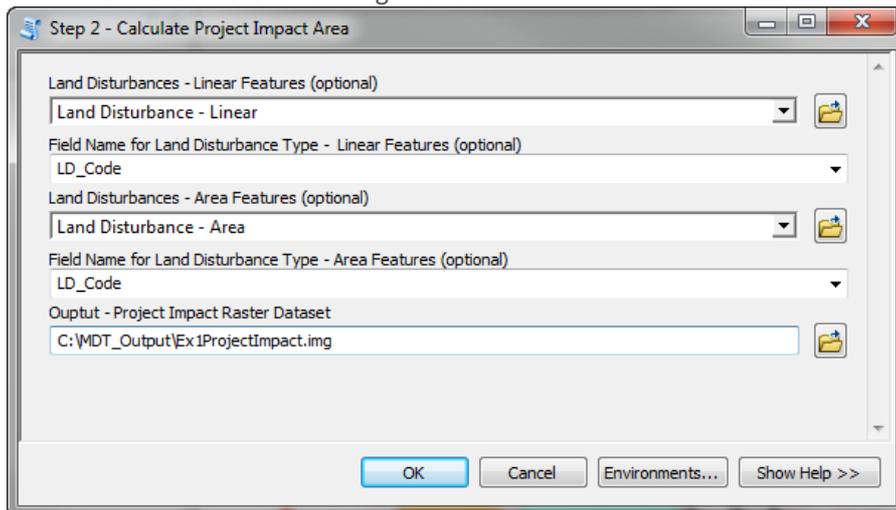
☐ Click the OK button. Hint: This took my computer approximately 3 minutes so grab a short break while this is running.

☐ Examine the output impact raster, Ex1ProjectImpact.img and answer the following questions:

- What is the resolution of the dataset (Hint: use the source tab within the layer properties dialog)?

- Which impact area covers the largest area (Hint: open attribute table and select the impact with highest cell count)?

- How many sq. meters does the high impact category cover (Hint: resolution * resolution * cell count)?

☐ With the project impact area calculated, we can now calculate the potential offset costs associated with this development. Open the **Step3 – Calculate Offset Cost Report** tool within Toolbox>MDT>Offset Tools. Set the Project Name to Oakleaf, select the Ex1ProjectImpact.img layer for the Project Impact Area Raster, set the Project Duration to Medium (5 – 20 years) and finally set the output file name to Oakleaf_Report.html. Your dialog should look exactly like the one below.
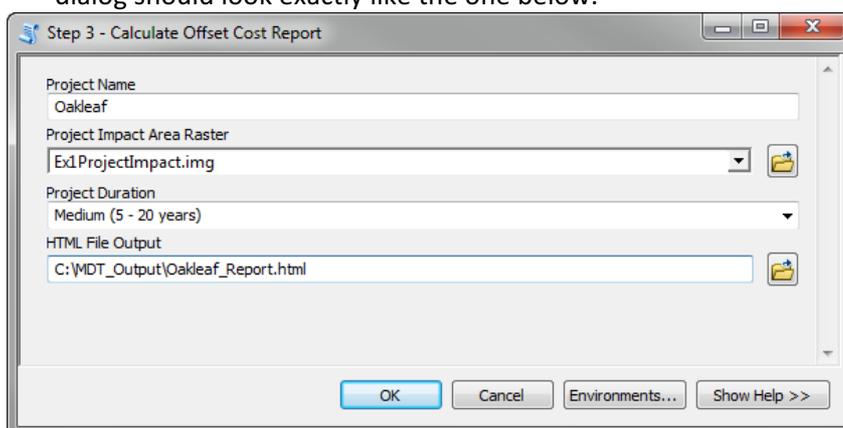
☐ Click the OK button.

☐ Using the report generated, scroll through it and answer these questions:

- What is the total offset cost per year for this project?

- What is the total offset units per year for this project?

- What are the total hectares of the area impacted?

- What is roughly the overall offset ratio for this project?

- Which offset factor (i.e. Ecosystem Category, Habitat Type, Landscape Condition, Landscape Priority, and Project Duration) contributed the most to the overall offset cost. What Soum are these impacts located in?

- What is the ecosystem impacted by this development?

☐   Now to identify where best to potentially apply these offset actions, **Open Step 4 (optional) – Identify Potential Offset Sites** within MDT>Offset Tools. Select the Ex1ProjectImpact.img as the Project Impact Area Raster, select your MDT_Output folder as the Output Folder and keep both items checked. Your dialog should look the same as below.
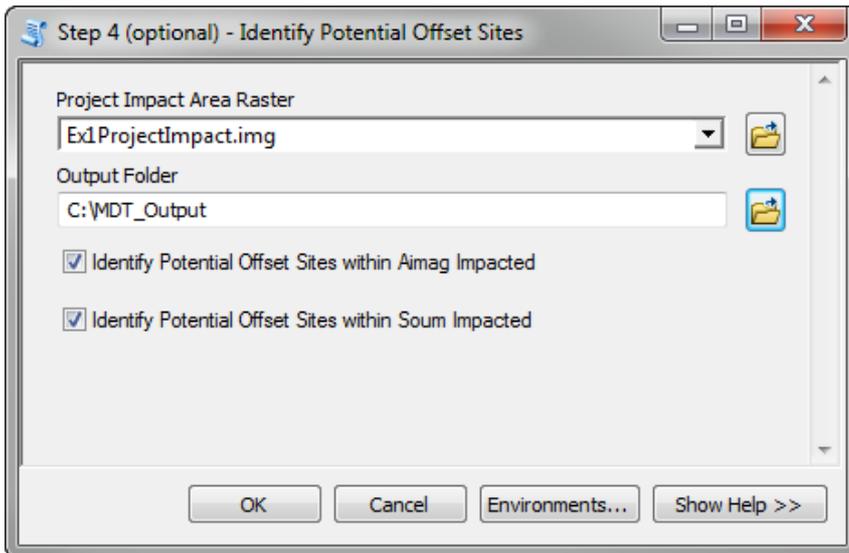
☐   Click on the Ok button.

☐   How many potential offset sites were selected within the Xu'rmen Soum ?

☐   Open the attribute table of the OffSites4_Xu-rmen_Soum_inGobi layer, using the dist_away field identify by the AREANAME field the closest potential offset site for the project impact area?

☐   How many potential offset sites can be found within O'mnogovi Aimag?

☐   Open the attribute table of the OffSites4_O_mnogovi_Aimag_inGobi layer, using the dist_away field identity the AREANAME of the closest potential offset site for the project impact area?

☐   How are these two potential closest offset sites different?

☐   Close ArcMap without saving.

Avoidance
☐   Open *EX2.mxd* within the MDT_Tutorials folder

☐   Open the Oakleaf Fake Mine – Linear Land Disturbance attribute table. Write down how many features are found in this layer.

☐ Open the Oakleaf Fake Mine – Area Land Disturbance attribute table. Write down how many features are found in this layer.

☐ Open the ArcToolbox window and select the MDT toolbox. Under the Land Disturbances and Impact Tools, double-click on **Step 2 – Calculate Project Impact Area**.

☐ Select the Oakleaf Fake Mine –Linear Land Disturbances for the Linear Features and the LD_Code field for the Field Name. Do the same for Area Features using the Oakleaf Fake Mine – Area Land Disturbances layer for the input. Finally set the Output to the name Oakleaf_Project_Impact.img and place it within the MDT_Output folder. Your dialog should look similar to the one below.
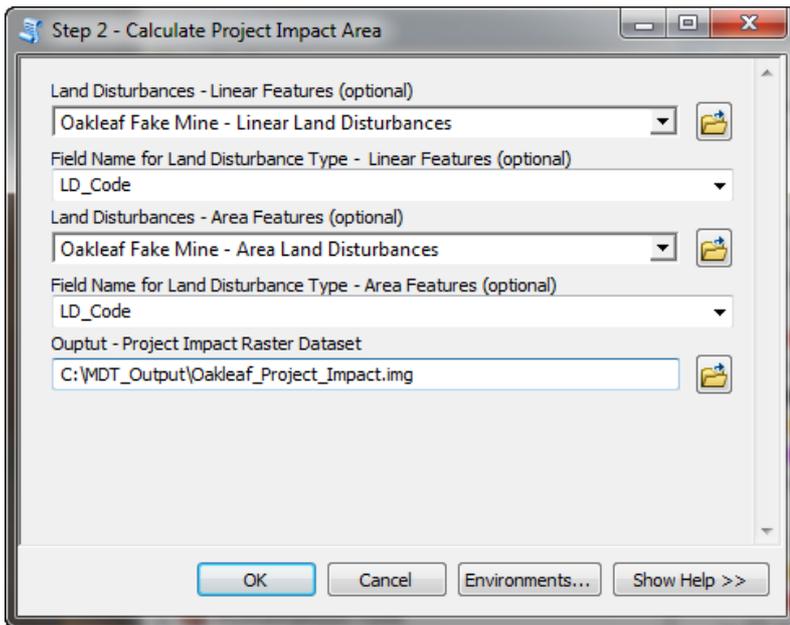
☐ Click the Ok button to run
☐ Examine the output dialog as this tool runs. It will inform you as each LD feature is used in creating a Project Impact Area

☐ If you drink coffee or tea, this would be a good time to go and get it ☺

☐ Once the application is finished write down how long it took to calculate the project impact area for these disturbances.

☐ Make the Oakleaf_Project_Impact.img the only visible layer and open its attribute table. Which impact category has the most area associated with it?

☐ Within the MDT Toolbox under the Offset Tools select the **Step 3 – Calculate Offset Cost Report** tool and set Project Name to Oakleaf Fake Mine, select the Oakleaf_Project_Impact.img layer for the Project Impact Area Raster, select Medium (5-20 years) for Project Duration, and output the HTML File to your MDT_Output folder naming it Oakleaf.html. It should match the dialog below.
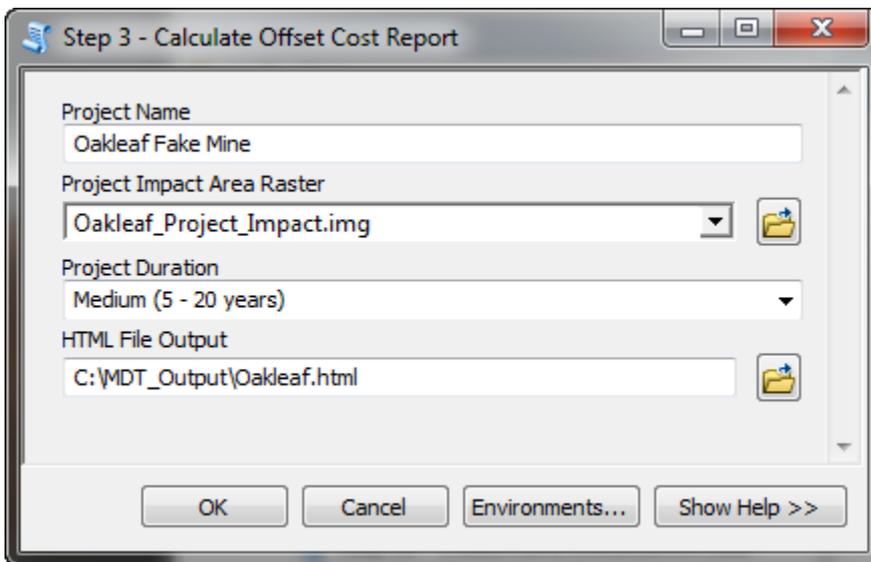
☐ Click the OK button

☐ Examine the output dialog as the tool runs

☐ When the report opens, scroll through it and answer these questions:

    o   What is the total offset cost per year for this project?

    o   What are the total hectares of the area impacted?

    o   What is the percent of impacts found within Xovsgol Soum?

    o   What is the ecosystem which is most impacted within Ulaanbadrax Soum?

☐ We are now going to look at ways to lower the costs associated with this project. Open the *Land Disturbances – Locational Offset Cost and Restrictions Assessment Tool* found within ArcToolbox>MDT>Supplementary Avoidance Tools. Input the appropriate values and output your Assessment to the name LC_CostAssessment.shp. Keep default items checked. Your dialog should look like the one below.
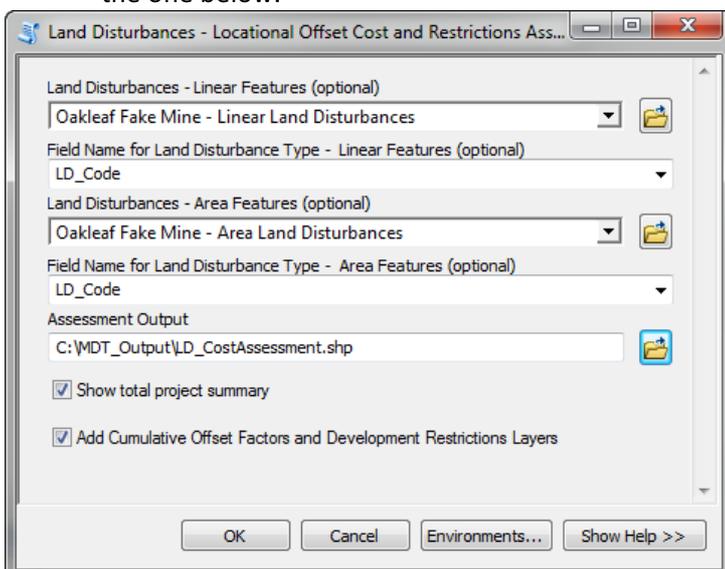
☐ Click on the OK button.

☐ How long did this tool take to complete?

☐ What was the total summary COF value for all land disturbances (Hint: This is displayed in the geoprocessing results dialog)?

☐ Which two disturbances result in the highest offset costs?

☐ Comparing the Temporary Camp with the Cumulative Offset Factors, what could you do to lower your offset costs with this land disturbance given it must stay connected to the same road?

☐ List any other potential spatial modification which could lessen offset costs?

☐ Are there any land disturbances crossing development restriction areas?

☐ Close ArcMap without saving.

☐ Now open EX2_modified.mxd.

☐ The land disturbance features were modified, list the changes you see:

☐ Now rerun the *Land Disturbances – Locational Offset Cost and Restrictions Assessment* using the modified land disturbances and assign the name of your assessment output to Modified.shp. This time uncheck the Add Cumulative Offset Factors and Development Restrictions Layers. Your dialog should look similar to the one below.
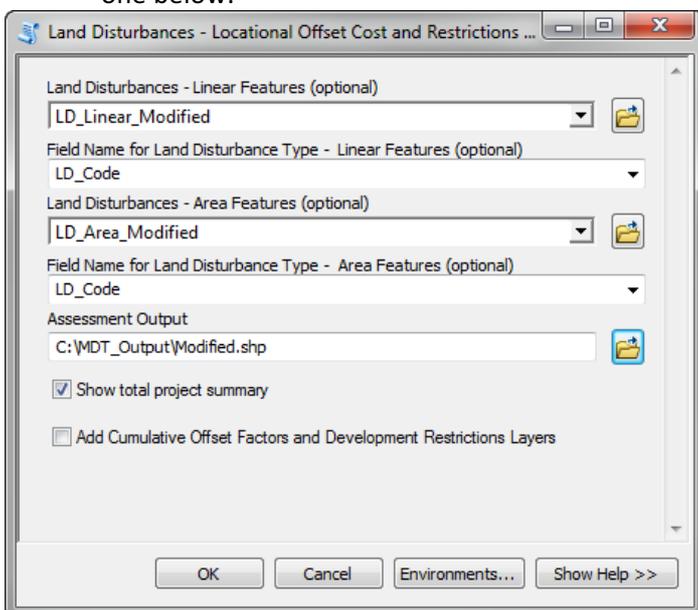
☐   Click the OK button.

☐   What is the new overall COF value?

☐   Which land disturbance feature now has the highest potential cost value?

☐   Now go through the steps and use the appropriate tools to create an offset cost report for these modified land disturbances.

☐   What is the new total offset cost per year with the modified land disturbances using the same duration values as before (i.e. Medium)?

☐   How much did that save in offset costs?

☐   Would there still be other ways to possibly save additional offset cots?

☐   Close ArcMap without saving.

Appendix D – Tutorial for QGIS 2.12 Users

Setup for Tutorial

☐ Go to QGIS website and download and install the most recent version of software (http://www.qgis.org/en/site/forusers/download.html#).

☐ Download MDT tutorial data at http://s3.amazonaws.com/DevByDesign-Web/MonOffsetDesign/data.html

☐ Un-package *mdt_tutorials.zip* in a read/write location on your computer (Hint: Answers for tutorial can be found in the *Solutions* folder within this zip file.

☐ Create an MDT_Output folder. This will be the folder for all data created in tutorial and be displayed within all dialogs as c:\MDT_Output.

Digitizing Land Disturbances in QGIS

(Note: If you do not need to learn how to digitize in QGIS or use domains jump to the next section of the tutorial, i.e. Using MDT-Web)

☐ Open the *ExDigitize.qgs* file. This QGIS file has a scanned and geo-referenced mine plan (i.e. FakeGoldMine_JRO Final) which is created only for this tutorial and is not real. To use MDT-Web, we will need to represent this mine plan in a GIS format.

☐ First we will create shapefiles to contain the varying land disturbances to be mapped.

    a. To begin digitizing features click on the New Shapefile Layer button

    b. From the New Vector Layer dialog (Fig. D1), select type Line, make sure the selected coordinate system is UTM zone 48 (should be the default), and add a new attribute with the following parameters: Name: LD_Code, Type: Whole number, Width: 2 (hint: you will need to click on Add to attributes list button once you input these parameters). Then select the id field and click on the Remove Attribute field. Check to make sure your dialog looks the same as Fig. F1 and click on the OK button and save your dataset as LD_Linear in the MDT_Output folder you created.
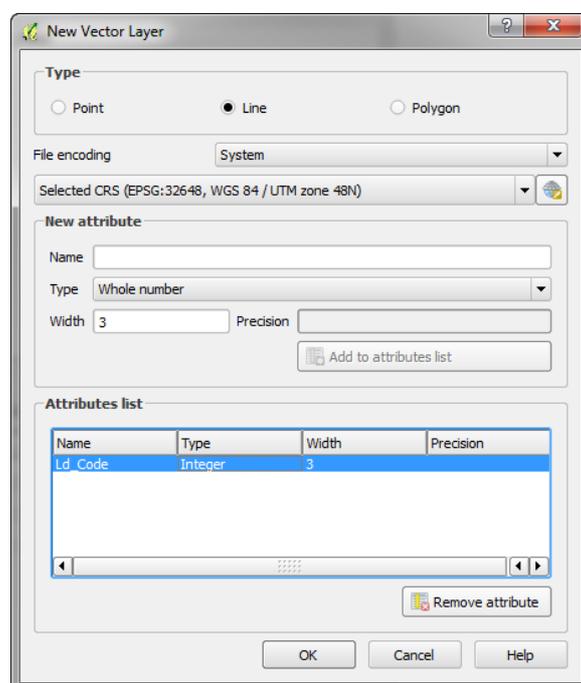
Fig. D1 New Vector Layer dialog.

c. Now set the following properties of the new LD_Linear layer by right-clicking on the layer and select Properties. Click on the Style tab and set the rendering to a Simple line with a color and width which can be seen can be seen and is wide enough (e.g. black, 1). Then select the Fields tab and select the LD_Code field. Click on the TextEdit button. Select the Value Map category from the list. Make sure the Editable and Label on top boxes are selected. Then click on the Load Data from CSV file and select lineLDcodes.csv file from the Data\ExQGIS_Digitizing directory. Before clicking OK make sure Your Edit Widget Properties – Ld_Code(Ld_Linear) dialog looks like Fig. D2.
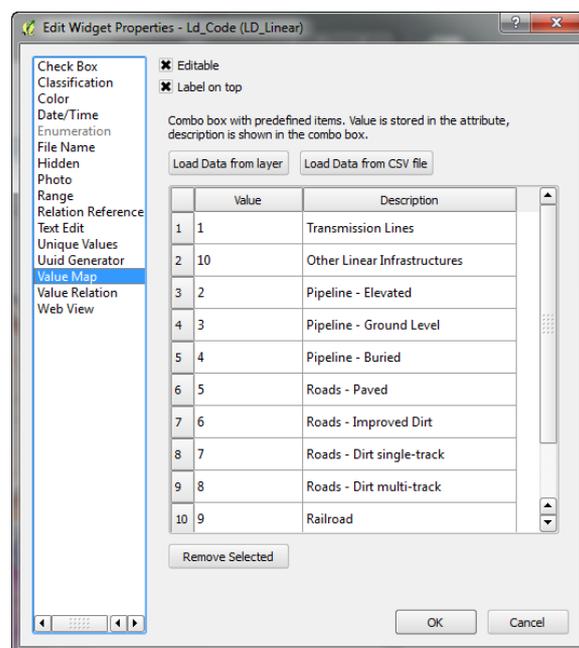
Fig. D2 Edit Widget Properties dialog.

d. Save these layer properties to a QGIS Layer Style File within the same folder you created this shapefile, keeping the name the same with the qml file extension (i.e. LD_Linear). This can be done by clicking on the Style menu button in the lower, left corner of the dialog (Fig. D3).
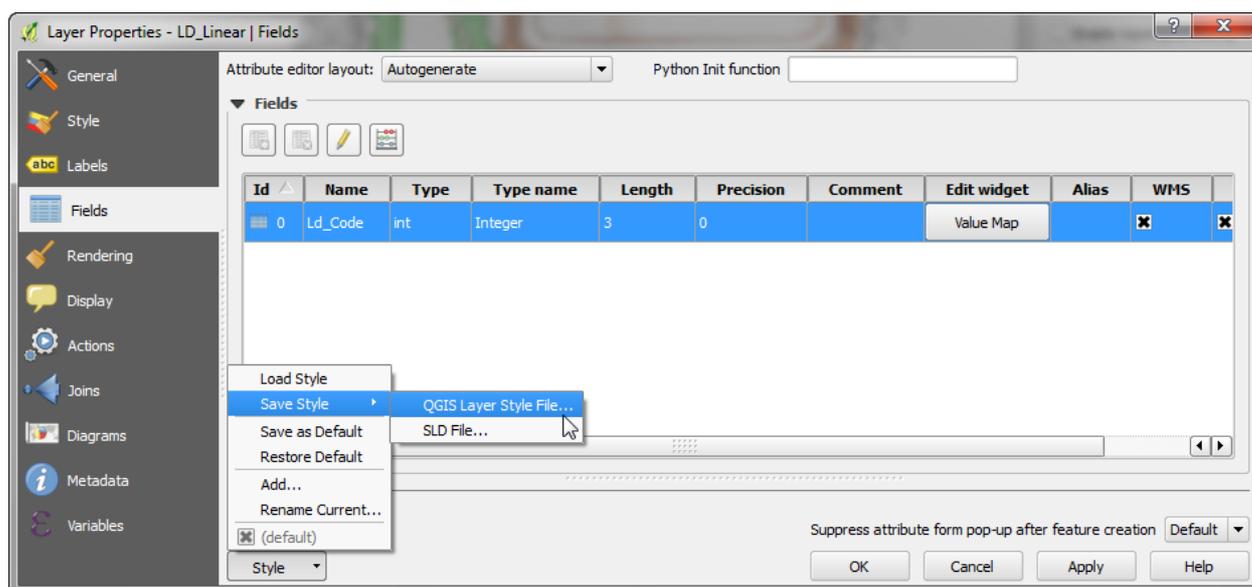
Fig. D3 Layer Properties dialog.

e. Repeat steps 5a – 5b with the following changes, set the New Vector Layer - Type to Polygon. Your dialog should look similar to the one below (Fig. D4). Save the shapefile to the name LD_Area.shp

f. Repeat step 5c but this time select Style which will allow for you to easily digitize polygons and for the field domain values (i.e. Value Map) select the areaLDcodes.csv file located in the QGIS_Demo/Data directory .

g. Save these layer properties to a QGIS Layer Style File within the same folder you created this shapefile, keeping the name the same with the qml file extension (i.e. LD_Area).
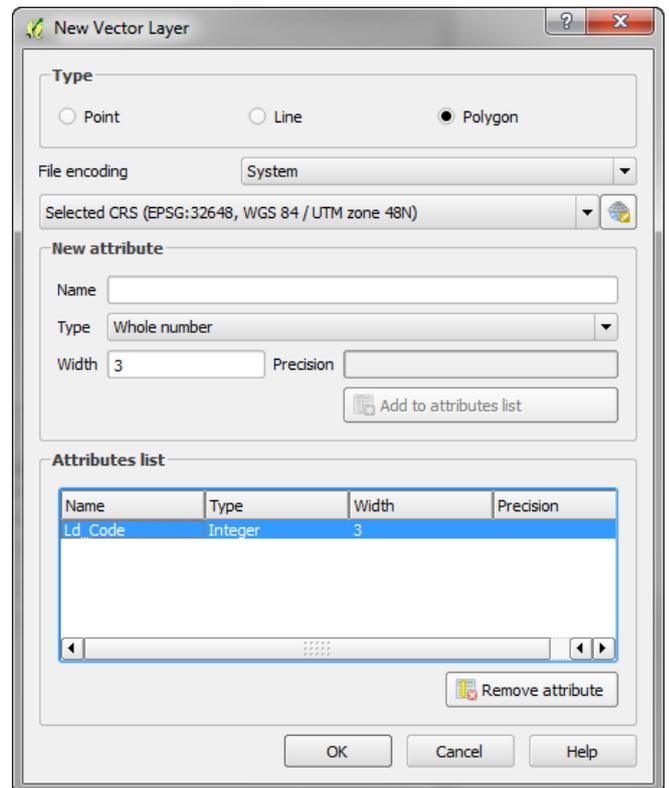
Fig. D4 New Vector Layer dialog.

☐ Prior to digitizing features you may want to set the Snapping options located under the Settings/Snapping Options menu. This will especially be beneficial when editing linear features such as roads to insure these features are connected. Although MD does not require topologically correct data it is still important to try to follow these standards (e.g. lines connect).

☐ Now digitize the linear land disturbances found within this image.
   a. First right click on the LD_Linear layer and select the Toggling Editing menu. This enables the editor toolbar.

b. Use the digitize feature tool ![icon] and follow the center-lines of the roads. To start a line feature, left mouse click and continue to left mouse click to add vertices to the line. To end the line, click the last vertex and then right click to end the line. When you right click you will be presented with a dialog to select the appropriate land disturbance type being digitize. Set the Southern major road type to Roads-Paved with all others set to Roads-Improved Dirt. In the end, your LD_Linear data will look similar to the map below (Fig. D5). Make sure to save your edits and toggle off your edit session.
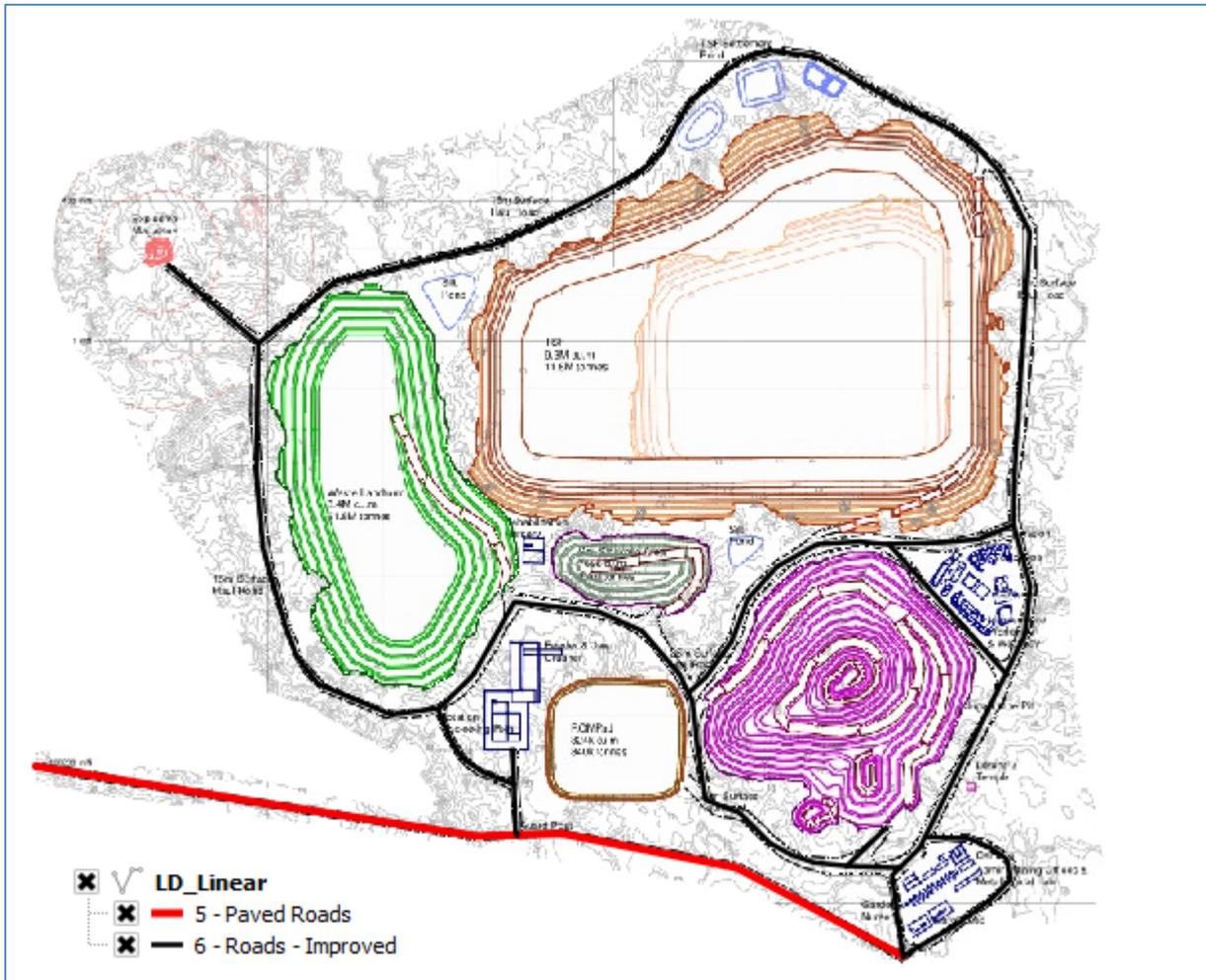
Fig. D5 LD Linear mapped features

☐ Now digitize the area land disturbances found within this image. Right click on the LD_Area layer and select Toggle Editing. The Editor toolbar will automatically change to the Polygon tool 🖫. Due to this being a tutorial be as accurate as you feel necessary to get capture the location of the features. Your end product data should look similar to the map below.

Fig. D6 LD area mapped features.

☐ You now have two shapefiles which can be uploaded to MDT-Web by placing them into a zip file.

☐ Create this zip file making sure to include all files with the base names having LD_Area and LD_Linear.

Using MDT-Web

☐ Open Ex3.qgs within the MDT_Tutorials folder

☐ Use QGIS to answer the following questions.

- How many area land disturbances are there?
- Which land disturbance is most present in this table?
- Just by looking, what type of area disturbance will modify the land the most?
- Roughly what is the total size of the area disturbed?

- What is the size of the mining pit?
- How many linear land disturbances are found at this site?

☐ Close Ex3.qgs without saving

☐ We are now going to use the MDT Web to examine avoidance needs and lower overall offset costs required for this site.

☐ Using your favorite browser window open the following url: http://s3.amazonaws.com/DevByDesign-Web/MappingAppsVer2/MDT_Mongolia/index.html

☐ Before running any MDT Analysis, use the web site to answer the following questions:

- How many map tools are available?

- How many input data maps are included?

- Turn on the Local Protected Areas layer and the Aimag Boundaries layer. Just by looking which two Aimags have the highest percent of their land designated as locally protected?

- What year was the Local Protected Areas layer created (Hint: Click on info button to the right of the layer name)?

- Zoom to a Latitude of 47 and Longitude of 93, answer these questions:

  • Which ecoregional assessment boundary is this location in?

  • What ecosystem type is found at this point?

☐ We will now use the MDT Analysis tools, how many tools are available?

☐ Click on the Upload Land Disturbances Data tool. Click on the Browse button and select the zip file *FakeGoldMineEx3.zip* located in your Exercises folder. Before running the tool, identify the Aimag this fake development scenario is located in.

☐ Now make sure the LD Code Field names are set to the field name DCode for both Area LDs and Linear LDs and then click on the Run LD Check button. How many errors are identified by the tool?

☐ Close the Upload and Check Land Disturbance Data dialog. What color are the error features?

☐ Examine the legend to the left, are there some features which seem misidentified, if so identify which ones?

☐ We will now fix all the attribute errors with these data:

- Click on the linear error feature, what is the current LD_Code for this feature?

- Click on the Edit LD Code button, select from the drop-down menu Roads-Improved Dirt and then click on the update button.

- Close this dialog. What color is this feature now?

- Click on the polygon error feature and set this feature to a Pile.

- Change the Pipeline linear land disturbance to a Roads – Paved.

- Click on the Airport area feature in the south-eastern quadrant of the planned development and change this feature to a Mining Pit

- Click on the Airport area feature in the western portion of the planned development and change this feature to a Pile.

- Your web map should look similar to the one below:

Land Disturbance Legend ▲

- Pipelines - All Types
- Railroad
- Roads - All Types
- Transmission Line
- Other Linear Infrastructures
- Airport - Strip and Buildings
- Fenced Area
- Facilities - All Types
- Leach Pad
- Mining Pit
- Oil Pad
- Parking - All Types
- Pile
- Pond
- Human Settlement - All Types
- Other Area Infrastructures
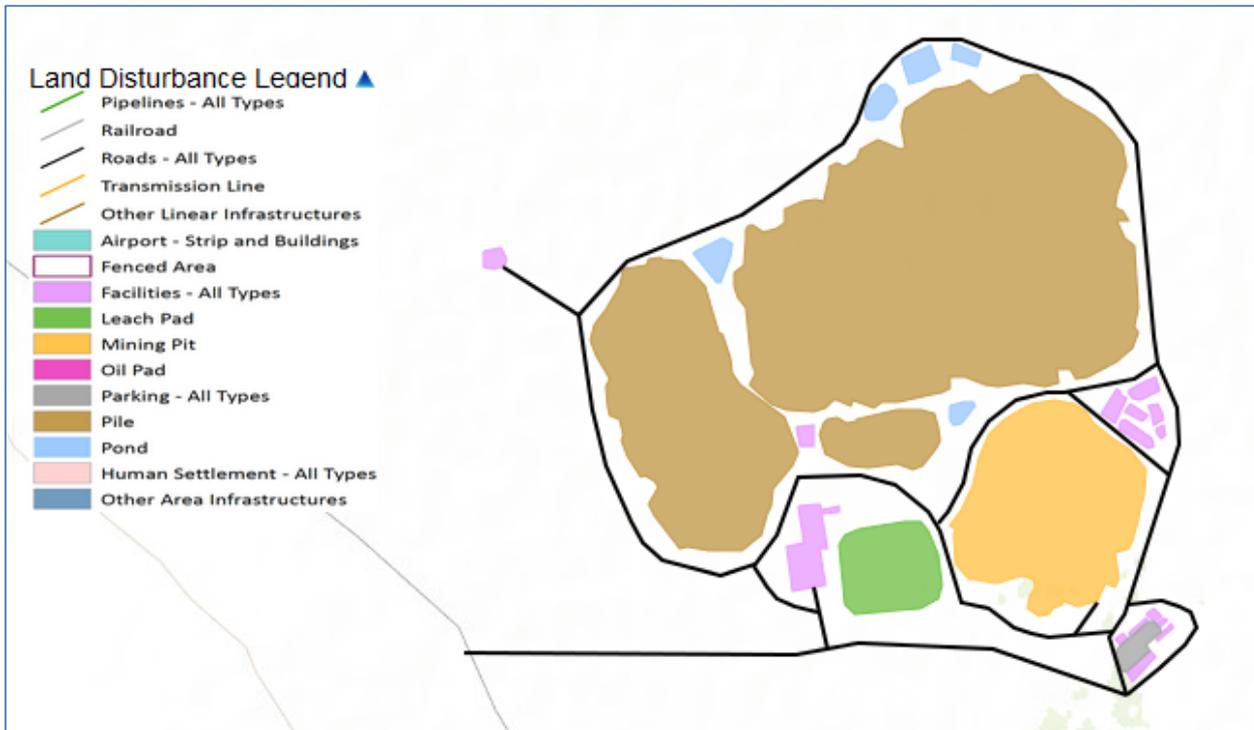
☐ Click on the Avoidance Analysis menu.   Identify the color of the icon following step one.

☐ Now to check your attribute edits, re-open the Upload Land Disturbances Data dialog.

☐ Click on Run LD Check and make sure the output does not identify any errors. If it does go back and make sure that you followed the attribute edits necessary to match the map above and then Run LD Check again.

☐ With these land disturbances displayed, now turn on the Cumulative Offset Factors layer. Identify which features look to be the most costly to offset?

☐ Turn on the Landscape Priority factor map, what category does this planned development fall into?

☐ Using either the layer information or other input data maps, identify why this planned development falls into this category?

☐ We will now check our assumptions by running the MDT Avoidance Analysis. Click on the Avoidance Analysis menu. Now what icon is found to the right of step one?

☐ Input an email account you can access via the computer you are currently assigned to. (Note: If you can't access your email on your assigned computer just type in your own email account and check files later when you return to work, you can access a replica of the output zip file (i.e. *mdt_avoid_data_originalEx3.zip*) under the Data>Ex3>output folder).

☐ Depending on the current web traffic and processing que of the application server this process could require some wait time.

☐ When you received the email, who was the sender of the email containing the avoidance data? dybd.tnc.apps@gmail.com

☐ What is the name of the attached file?

☐ Open the attached file and identify how many files are within this zip file?

☐ Click on the total_summary.txt to open. What is the cumulative offset factor value of this development?

☐ Minimize your web browser window and now open Ex3b.qgs.

☐ Using the ld_avoid layer and its attribute table answer the following questions:

   ▪ How many impact areas from the disturbances (i.e. ld_avoid) are placed in the high category for the average costs?

- Where are these high category impacts located within the planned development?
- Of these high categories how many of them derive from area disturbances (Hint: LinkID relates to the type of disturbances and the original disturbance feature id)?
- Which land disturbance feature ranks the highest for its offset costs?
- Do any of the impacts overlap a protected area?
- What restricted areas do the impacts overlap?

☐ Close Ex3b.qgs without saving.

☐ Maximize your web browser with MDT – Web open. We will now load a different mine plan which avoids some of the higher cost areas. Click on the Upload Land Disturbances Data menu. Which zip file is it currently using?

☐ Click on the Browse button and select the zip file *FakeGoldMineEx3Avoid.zip* located in your Exercises folder.

☐ Set the LD Code Fields to Ld_Code and click on the Run LD Check button. Where there any errors?

☐ Identify some of the changes you see with this new impact design?

☐ Since we now have a final design for our planned development, we will now run the Offset Analysis. Click on the Offset Analysis menu.

☐ Set the project life to Medium (5-20 years), input any project name you want, and again input an email account you can access from your current computer. Click on the Run Offset Analysis button. Note: If you can't access your email on your assigned computer just type in your own email account and check files later when you return to work, you can access a replica of the output zip file (i.e. *mdt_offset_data.zip*) under the Data>Ex3>output folder .

☐ While the application is running, open the replica zip file(i.e. *mdt_offset_data.zip,* under the Data>Ex3>output folder) and answer these questions:
- How many files are within this zip file?
- Open the mdt_offset_cost.html file and answer these questions:
  - What is the total offset costs per year for this development?
  - Which offset category had the highest number of offset units required?
  - Within which Soum do all the impacts occur?
  - What are the total hectares impacted by this planned development?
  - Which ecosystem type is most impacted by this planned development?
- Open the offset_info.txt file and answer these questions:
  - What three shapefiles within the zip file identify potential offset locations?
  - How many offset sites did the application identify for Xovd aimag?

☐ Close the replica zip file.

☐ Open *Ex3c.qgs* which display the output data from the MDT-Web offset analysis and answer the following questions:
- Which impact category is the largest in terms of area?
- Which offset site is the closest to this development?
- What is the category of the offset site closest to the development?
- What is the name of the next closest identified offset site within the Aimag?

☐ Close *Ex3c.qgs*

Appendix E – Additional MDT Documents

Table E1. Additional MDT Documents produced for this project with description. All documents produced by this project available at [Mongolia Mitigation Design Tool Web Portal](Mongolia%20Mitigation%20Design%20Tool%20Web%20Portal).

Document	Document Description
MDT – Desktop Help Documentation	Full documentation for using MDT – Desktop application within ArcGIS (English & Mongolian version available)
MDT – Web Help Documentation	Full documentation for using MDT – Web application (English & Mongolian version available)
Application Development Plan for MDT-Desktop	Initial plan for development when creating Gobi only version of application (English only).
Application Development Plan for MDT-Web	Initial plan for development when creating Gobi only version of application (English only).