

**Delineation of high tide line using DGPS and
Laser Trak instruments: With special reference to
Mapping Techniques.**

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ABSTRACT :

Delineation of High Tide Line (HTL), Low Tide Line (LTL) and demarcating the Coastal Regulation Zone (CRZ) boundaries for any part of the Indian coast has to be dealt with great care. This technical report suggests the method adopted by us for delineating the HTL, LTL and measuring the setback lines. Some suggestions are made regarding different instruments available for carrying out this task and the best possible method and selection of instruments for delineating the HTL. A Program namely “ Conversion of Laser Trak raw data to obtain the final UTM co-ordinates” is indigenously developed by the author for processing the collected raw data, the listing of the software is being given in this technical report. When it comes to mapping the final output, A suggestion is being made in this report for an urgent need that CRZ issues should be taken up as a National programme with all mapping agencies using same methodology, same datum, same projection and with similar interpretation, so that, uniform rules can be followed in all the states for HTL demarcation. This will enable all the CRZ maps prepared from any part of our Indian coast, getting depicted uniformly in accordance with CRZ regulations.

1.0 INTRODUCTION :

During the period 1998 to 2002, to meet the requirements of Coastal Zone Regulation, many industrial firms, approached National Institute of Oceanography, Dona Paula, Goa, the authorised agency of MOEF to delineate the High Tide Line (HTL) , Low Tide Line (LTL) and to measure the setback from high tide line along the coast for their projects.

National Institute of Oceanography physically demarcated the HTL, LTL and measured the Coastal Regulation Zone boundaries and successfully submitted their reports to all their clients.

Eventhough several methods and instruments are available for delineating the HTL, the method opted by us for fixing the high tide line, using Trimble DGPS for fixing the ground control stations all along the coast of the survey area at specific intervals and then using Wild T-2 Theodolite and Laser Trak optical instrument (over the selected ground control stations) with multi-prism reflectors, over carefully identified High Tide Line (HTL) marks, is one of the most successful as well, fast, accurate and reliable method.

This technical report has been made based upon the experiences gained from the successful completion of about 20 such projects. The main need for preparation of this report is to highlight the technical aspects involved, the method of survey and the indigenous software developed by the author to process the field data.

When it comes to mapping the final output, I like to suggest in this report for an urgent need that CRZ issues should be taken up as a National programme with all mapping agencies using same methodology, same datum, same projection and with similar interpretation, so that, uniform rules can be followed in all the states for HTL demarcation. This will enable all the CRZ maps prepared from any part of our Indian coast, getting depicted uniformly in accordance with CRZ regulations.

2.0 APPROACH :

Comprehensive studies for a coastal development and management require the detailed information on the HTL, LTL and CRZ boundaries and the classification of coast at least up to 500 m landward distance from HTL.

The first step in such a study is to collect the physical portion of HTL, LTL and the relevant information to meet the requirement of coastal zone regulation.

3.0 METHODOLOGY :

3.1.DELINEATION OF HIGH TIDE LINE::

i). Horizontal control : The horizontal location of the base line co-ordinates can be fixed by Trimble DGPS (Differential Global Positioning System) and the extension of the base line co-ordinates, using DGPS, Wild T-2 Theodolite and Laser Trak. The horizontal control of all the HTL marks can be obtained using Laser Track optical instrument, from the base line positions.

.ii) Vertical control : The vertical control is essential to provide the height information for contours and spot heights in topographical mapping. For this purpose, the Tidepole, Automatic level with staff and levelling shoes, Marker line and Tide table can be used.

.iii) Information : The following informations should be collected in the field: The basic data on morphological variations description, ground survey and sediment samples, wind driven water circulation, environmental cut and fill (current wave and long shore current), vegetation stabilization, berm crest, crest of wash over terraces and coastal structures.

The wet/dry boundary observed from the available base map of CRZ may be used for the first approximation of HTL position. However, for the final confirmation, the highest range of spring tide and its horizontal run up on the land should be identified by way of morphological features; permanent vegetation line and flotsam as per the existing guide lines of the Ministry of Environment

Demarcation of HTL can be carried out by using the wild T2 theodolite and Laser trak and the data should be collected and presented by following the settled principles in the matter of survey of this nature

For all CRZ related surveys, as a first step, the calibration of all the survey equipments has to be carried out before commencing the actual survey, to eliminate all types of errors, while collecting the raw data. Then, the base line co-ordinates A and B can be very precisely obtained using Trimble DGPS (Differential Global Positioning System), which forms the main base line co-ordinates, for the delineation surveys. Secondly, using the base line positions, the extension of reference points can be carried out throughout the survey stretch, using Wild T-2 Theodolite. Then the raw data can be collected systematically using LaserTrak (MK III model) over carefully identified HTL (High Tide Line) marks

The raw data consists of the following: I) The uncorrected raw range (D), ii) the

horizontal angle (H) (between the base line points A and B and the HTL mark, subtended at the laser Trak instrument station (A) and iii) the vertical angle (V) (of the HTL mark from the Laser Track station). This raw data can be taken to the lab, for further processing and to prepare the final CRZ maps.

A Program "Conversion of LaserTrak raw data to obtain final UTM co-ordinates" which was individually generated by the author, was used for obtaining the final corrected output values. The final corrected HTL positions can be used for preparation of final charts using HP Plotter. The listing of the Program is given in Chapter 4.0 of this Technical Report.

3.2. DELINEATION OF LOW TIDE LINE:

The lowest tide level (LTL), is the lowest Astronomical low water, which almost coincides with the chart datum. This datum is used for reduction of tidal oscillations during the bathymetric charting. Since the low water line will be occasionally exposed for physical demarcation, the convenient way to demarcate LTL will be by way of carrying out the beach profiling or the bathymetric charting in the inter-tidal zone. The method of beach profiling is already explained in the text of delineation of High Tide Line. The Admiralty Manual of Tide Tables may be referred for reduction of soundings to Chart Datum and bathymetric charting. Also, the Admiralty Manual of Hydrographic Surveying Vol. I & II may be referred for further details.

3.3 DELINEATION OF CRZ (COASTAL REGULATION ZONE) BOUNDARIES: :

By any set of criteria, the coastal zone is a linear band of land and water paralleling the coast. The land and ocean interface has two principal axes:

1. Along the shore
2. Perpendicular to the shore (Cross line)

The designated CRZ boundary lines will be delineated parallel to the HTL configuration uniformly along the coast. The present CRZ boundary limits extend up to 500 meters from the HTL in the open coast and to a distance of 100 meters from the HTL in creeks, river and backwaters. For further details on classification of CRZ boundaries (from CRZ I to CRZ IV) and the permissible limits for any construction activity ,etc., the Ministry of Environment and Forests (MOEF) Notification issued by the concerned State MOEF, may be referred.

4.0 EQUIPMENT USED:

4.1 TRIMBLE DGPS (DIFFERENTIAL GLOBAL POSITIONING SYSTEM):

A Trimble make DGPS, Series 4000 receiver was used for obtaining the geographical co-ordinates (Horizontal control) of the base stations, to extreme precision.. This instrument can perform the most precise static surveying and also, the slowest. After setting up the instrument on the base station, it requires observations of atleast four satellites for a period of about 60 minutes. There are two types of static surveys : single and dual frequency. Single-frequency static surveys are appropriate for surveys with base lines shorter than about 15 kms, under good atmospheric conditions. They yield base lines, that are precise to better than + 2cms + 2ppm. Dual-frequency static surveys are required to ensure accurate results in geodetic control surveys, with base lines upto 30 kms or more under good atmospheric conditions. They yield base lines, that are precise to better than + 5mm + 1ppm. The observation and simultaneous data logging time, recommended for these surveys is atleast 45 minutes, during times when five or more satellites are available, or 60 minutes, during times when only four satellites are available.

4.2 WILD T-2 UNIVERSAL THEODOLITE:

A wild T2 Universal theodolite with automatic index can be used for the extension survey. This instrument is extremely useful for extending the base stations from the main grid to convenient nearshore locations, by carrying out Triangulation surveys The least count of this instrument (while measuring horizontal and vertical angles) is 0.2 second. For further clarifications on its Technical specification, refer Wild T-2 Universal Theodolite operation manual, which is being issued along with the instrument.

4.3 LASER TRAK:

The tripod mounted Laser Trak instrument, located at fixed reference points, provides fast, accurate and logistically simple positioning of high tide line locations. This instrument can also be used to get the position of survey vessels and barges, from a fixed reference location. Other applications include hydrographic surveying of lakes,

rivers and harbours and precision positioning of offshore structures and construction barges. LaserTrak is an electronic instrument which measures distance by timing the passage of a light pulse fired at a target and its return. The angles are measured by optical encoders and elevation by electrolytic liquid level sensors and / or optical encoders. LaserTrak has its own integral UHF data telemetry system and has facilities to interface a gyrocompass and computer system directly via cable.

TECHNICAL SPECIFICATIONS :

I) LASER TRAK

Type	: Semiconductor
Accuracy	: + 20 cms. (High Accuracy option, + 1 cm.)
Resolution	: 0.1 meter.
Range – Standard Class I	: 100 m. (non-reflective targets) : 1500 m. (with single prism reflector) : 5000 m. (with multi-prism reflector)
High Power Class III A	: 400 m. (non-reflective targets) : 2500 m. (with single prism reflector) : 10000 m. (with multi-prism reflector)
Measuring Time	: 0.5 seconds.

II) VERTICAL ANGLE :

Type	: Automatic Electrolytic sensor
Accuracy	: 0.25 degs. (0.01 degs. optional)
Resolution	: 0.01 degs.
Range	: +40 degs.

III) HORIZONTAL ANGLE :

Type	: Encoder
Accuracy	: 0.01 degs.
Resolution	: 0 degs. to 360 degs.

IV) CONTROL DISPLAY UNIT :

Display	: Backlit LCD 2 * 20 characters
Keyboard	: 2 * 8
Processor	: 8048

V) ENVIRONMENTAL :

Operating Temperature	: 0 to 45 degs. C
Power consumption	: 12 V DC 1 Amp.
Battery charger Module (BCM)	: 6 Amp HR sealed lead acid

Practically, it was found that LaserTrak is one of the most reliable and useful equipment, especially for carrying out surveys to delineate the high tide line. The speed with which a survey can be performed using this instrument, makes it, an ideal equipment for these type of surveys, where vast stretch of area can be covered in a short time. Also, this instrument can be used quite effectively for carrying out beach profile surveys and bathymetric surveys at inter tidal zones from well established permanent locations, on the shore.

5.0 SOFTWARE DEVELOPED

5.1 LISTING OF THE SOFTWARE :

The Program “ Conversion of LaserTrak raw data to obtain final UTM coordinates “ was indigeneously developed by the author and is given below :

```

5  REM PROGRAM FOR OBTAINING FINAL UTM CO-ORDINATES OF HTL FIXES.
10 REM INPUT : RAW DATA FROM LASER TRACK EQUIPMENT.
15  DEFDBL A-H
20  DEFDBL J-Z
25  AB$=" #####  #####.##  #####.###  #####.###  ###.##  ###.## "
30  CD$=" #####  #####.##  #####.###  #####.###  ###.## "
35  PRINT " HIGH TIDE LINE SURVEYS IN RATNAGIRI, MAHARASHTRA "
40  PRINT
45  REM INPUT H = HORI. ANGLE, V = VERTICAL ANGLE AND D = RAW RANGE.
50  PRINT " FIX H.DIST EASTING (M) NORTHING (M) AZI (DEGS) AZAC(DEGS) "
55  PRINT "GIVE INPUT FILE NAME" : INPUT INFILE$
60  OPEN INFILE$ FOR INPUT AS #1
65  OPEN "RATNAGIRI.OUT" FOR OUTPUT AS #7
70  PRINT #7, " HIGH TIDE LINE SURVEYS IN RATNAGIRI (MAHARASHTRA) "
75  PRINT #7, "

```

```

80 WRITE #7, " FINAL OUTPUT AFTER CONVERTING INTO UTM VALUES "
85 PRINT #7,"
90 WRITE #7, " FIX NO. DIST. EASTING  NORTHING  AZI."
95 PRINT #7, "          (mts.) (mts.)      (mts.)   (degs.) "
100 PRINT #7, "-----"
105 PRINT #7, "
110 FOR I = 1 TO 295
115 INPUT #1,F,H,V,D
120 IF F > 2099 AND F < 2113 THEN GOTO 175
125 IF F > 2112 AND F < 2122 THEN GOTO 195
130 IF F > 2121 AND F < 2141 THEN GOTO 215
135 IF F > 2140 AND F < 2168 THEN GOTO 235
140 IF F > 2167 AND F < 2210 THEN GOTO 255
145 IF F > 2209 AND F < 2240 THEN GOTO 275
150 IF F > 2239 AND F < 2255 THEN GOTO 295
155 IF F > 2254 AND F < 2289 THEN GOTO 315
160 IF F > 2288 AND F < 2337 THEN GOTO 335
165 IF F > 2336 AND F < 2371 THEN GOTO 355
170 IF F > 2370 AND F < 2395 THEN GOTO 375
175 H = (H+0)
180 EA = 386627.22# :: NA = 1674150.02#
185 EB = 386762.79# :: NB = 1674259.1#
190 GOTO 395
195 H = (H+0)
200 EA = 386574.1#  :: NA = 1674144.75#
205 EB = 386627.22# :: NB = 1674150.02#
210 GOTO 395
215 H = (H+0)
220 EA = 384605.64# :: NA = 1669930.49#
225 EB = 384458.67# :: NB = 1669086.31#
230 GOTO 395
235 H = (H+0)
240 EA = 384416.96# :: NA = 1670274.2#
245 EB = 384605.64# :: NB = 1669930.49#
250 GOTO 395
255 H = (H+0)

```

```
260 EA = 384416.96# :: NA = 1670274.2#
265 EB = 384605.64# :: NB = 1669930.49#
270 GOTO 395
275 H = (H-.01)
280 EA = 385442.1# :: NA = 1671090.76#
285 EB = 385639.35# :: NB = 1671023.55#
290 GOTO 395
295 H=(H+.01)
300 EA = 385442.1# :: NA = 1671090.76#
305 EB = 385639.35# :: NB = 1671023.55#
310 GOTO 395
315 H = (H+0)
320 EA = 386177.21# :: NA = 1671789.54#
325 EB = 386182.97# :: NB = 1672042.24#
330 GOTO 395
335 H = (H+.01)
340 EA = 386143.02# :: NA = 1672445.79#
345 EB = 385442.1# :: NB = 1671090.76#
350 GOTO 395
355 H = (H+0)
360 EA = 385906# :: NA = 1673093.4#
365 EB = 385442.1# :: NB = 1671090.76#
370 GOTO 395
375 H = (H+0)
380 EA = 386574.1# :: NA = 1674144.75#
385 EB = 386627.22# :: NB = 1674150.02#
390 GOTO 395
395 P = 3.14159265358#
400 X = 4.848136811095337D-06
405 G = (H*3600)*X
410 J = (V*3600)*X
415 R = (D*COS(J))
420 IF EA > EB THEN GOTO 435
425 ED = (EB-EA)
430 GOTO 440
435 ED = (EA-EB)
```

```

440 IF NA > NB THEN GOTO 455
445 ND = (NB-NA)
450 GOTO 460
455 ND = (NA-NB)
460 LET N=(ED/ND)
465 A = ATN(N)
470 AZI = (180/P)*A
475 IF NB > NA AND EB > EA GOTO 500
480 IF NB < NA AND EB > EA GOTO 510
485 IF NB < NA AND EB < EA GOTO 520
490 IF NB > NA AND EB < EA GOTO 530
495 GOTO 535
500 AZI = (AZI+0)
505 GOTO 535
510 AZI = (180-AZI)
515 GOTO 535
520 AZI = (180+AZI)
525 GOTO 535
530 AZI = (360-AZI)
535 AZ = ((AZI+H)*3600)*X
540 AZAC = (180/P)*AZ
545 E3 = R*SIN(AZ)
550 E3 = R*SIN(AZ)
555 N3 = R*COS(AZ)
560 IF AZAC < 0 THEN AZAC = (360+AZAC)
565 EC = (EA+E3)
570 NC = (NA+N3)
575 IF AZAC > 360 THEN AZAC = (AZAC-360)
580 PRINT USING AB$;F,R,EC,NC,AZI,AZAC
585 PRINT
590 PRINT #7,USING CD$;F,R,EC,NC,AZI
595 PRINT #7, " "
600 NEXT I
605 END

```

5.2 DEFINITION OF SYMBOLS USED :

In the above program,

“F” denotes the Fix number (identification number of every mark on the HTL).

“H” denotes the Horizontal angle (between baseline co-ordinates A, B and the HTL mark) subtended at Laser Trak station “A”.

“V” denotes the Vertical angle (subtended at the Laser Trak instrument station “A” between horizontal plane to HTL mark)

“D” denotes the raw range (from the Laser Track instrument to the HTL mark.

“R” denotes the corrected horizontal distance from instrument station to HTL mark.

“AZI” denotes the Azimuth AB (Inclination of the base line at point A, measured always clockwise from true north. from 000 degree. to 360 degrees.)

“AZAC” denotes the Azimuth AC (Inclination of AC at point (Station)” A” towards “C” (which is the HTL mark.) from true north 000 degree. to 360 degrees. clockwise.

“EA” denotes the Easting co-ordinates of A (obtained using DGPS inst.)

“NA” denotes the Northing co-ordinates of A (obtained using DGPS inst.)

“EB” denotes the Easting co-ordinates of B (obtained using DGPS inst.)

“NB” denotes the Northing co-ordinates of B (obtained using DGPS inst.)

“EC” denotes the Easting co-ordinates of Point C (final corrected Easting co-ordinates of the HTL mark obtained through the above program)

“NC” denotes the Northing co-ordinates of Point C (final corrected Northing co-ordinates of of the HTL mark obtained through the above program)

5.3 FINAL OUTPUT DERIVED :

A sample final output file (after converting using the above program) is given below : (F,R,EC,NC,AZI)

[FIX NO : Identified High Tide Line mark fix numbers; “F”

DIST. (mts.) : Corrected horizontal distance from base station “A” to HTL fix; “R”

EASTING (mts.): Final Easting co-ordinates of HTL fix; “EC”

NORTHING (mts): Final Northing co-ordinates of HTL fix; “NC”

AZI (Degs) : Azimuth of the base line, from base station “A” to”B” measured at “A”]

The final output will look like this:

HIGH TIDE LINE SURVEYS in Ratnagiri (Maharashtra) PROGRAM BY:PG.

“FINAL OUTPUT AFTER CONVERTING LASER TRAK DATA INTO UTM VALUES”

“ FIX NO.	DIST.	EASTING	NORTHING	AZI.”
(mts.)	(mts.)	(mts.)	(mts.)	(degs.)
2100	178.50	386743.451	1674285.486	51.18
2101	171.42	386739.322	1674279.709	51.18
2102	159.20	386733.826	1674268.253	51.18
2103	140.39	386726.819	1674248.962	51.18
2104	125.42	386723.595	1674230.289	51.18
2105	107.20	386713.338	1674213.861	51.18

(Note : Fixes from 2106 to 2376 is not shown here for want of space)

“FIX NO.	DIST.	EASTING	NORTHING	AZI.”
(mts.)	(mts.)	(mts.)	(mts.)	(degs.)
2377	1008.92	385897.378	1673396.444	84.33
2378	990.07	385919.302	1673402.139	84.33
2379	976.97	385939.942	1673401.571	84.33
2380	960.09	385960.897	1673405.993	84.33
2381	932.65	385983.704	1673422.766	84.33
2382	906.20	386000.935	1673442.838	84.33
2383	853.99	386049.219	1673471.100	84.33

2384	843.89	386067.834	1673469.591	84.33
2385	819.05	386091.929	1673482.662	84.33
2386	810.97	386106.351	1673482.270	84.33
2387	748.89	386164.972	1673517.490	84.33
2388	727.65	386194.181	1673524.153	84.33
2389	706.40	386217.870	1673534.751	84.33
2390	687.56	386249.783	1673538.485	84.33
2391	668.15	386283.359	1673543.169	84.33
2392	601.58	386328.992	1673595.370	84.33
2393	564.78	386344.165	1673628.896	84.33
2394	542.09	386360.860	1673646.366	84.33

The above program was quite effective in conversion of raw data obtained from Laser Trak equipment (while delineating the High Tide Line) to obtain final UTM co-ordinates for about 20 projects.

6. MAPPING TECHNIQUE :

6.1 SCALE OF SURVEY :

The scale adopted for a survey of a particular area should not be smaller than the scale of the existing or proposed chart of the area and should be atleast twice as

large as that of the largest scale of the published or proposed chart of the area. Also, the scale of the offshore plotting sheet should not be smaller than what is necessary to provide a sheet of convenient size. The chart should also show a short distance beyond the offshore limit of the survey and will, where feasible, include the stations necessary for the control of the survey. The final charts showing the low tide line, high tide line, the CRZ boundaries and all the prominent land features may be prepared on WGS – 1984 datum or local datum on scale of 1:4000, 1: 5000 or 1: 10000, depending upon the requirement and extent of the survey. However, there is a need for mapping anywhere throughout the Indian coast with a same uniform methodology, with standard datum and a standard scale.

6.2 NATIONAL PROGRAMME FOR UNIFORM METHODOLOGY:

A map is the first tool for management. Survey of India maps on scale of 1:25,000 based on topo sheet on scale of 1:50,000 are available. While this may be adequate for CRZ planning, it is not adequate for large scale maps of scales larger than 1:25,000, specially for those required in Urban areas and coastal cities. CRZ maps showing wetland features between HTL and LTL and land use features up to 500 mtrs. from HTL on scale of 1: 25,000 scale for the entire Indian coast have been prepared using IRS LISS II and SPOT data by the Naval Hydrographic Office at Dehra Dun. However, the planimetric accuracy of these maps can be used only for macro level planning and not for town planning and for specific projects. The navigation charts covering the entire Indian coast have been prepared by Naval Hydrographic Office on varying scales. The scales for harbour charts being 1:25,000 and on other bathymetric charts on a scale of 1:1,50,000 scales. Aerial photographs on scale of 1:50,000 and 1:25,000 for the entire India are also available. Cadastral level maps on scale of 1:3960 prepared by state authorities are also available. However, these datas are of different vintage, for example the source data for Survey of India topo-sheet is of 1970 to 1980 period, the data collected by National Hydrographic Office is of 1994 to 1995 period and the data collected through satellite is of 1996 period. Eventhough Imagary Satellite data is available even from 1996 onwards,.the data from various sources is collected on different projections and different datums. There are cartographic problems in matching the large-scale cadastral maps prepared using different sources and at times the distortions up to 300 mtrs have been experienced. This type of distortions is not suitable for town planning. The different source data used by different states will create

complications in adjoining areas. The problem is further complicated where the authorities authorized to prepare town maps in various states have different training background, expertise and experience varying from coastal state to state (Srinivasan, 1998). Therefore, there is an urgent need that CRZ issues to be taken as National programme with all mapping agencies using same methodologies, same datum, same projection and with similar interpretation, so that, uniform rules are followed in all the states so that all the CRZ maps prepared from any state, gets depicted uniformly in accordance with CRZ regulations. For the purpose of uniform training and understanding, I suggest a National Programme, in which, imparting training to field surveyors and land marking authorities should be one of the main agenda. This proposal, once implemented, will ensure that the field surveyors and land authorities all over the country will adopt the same yardsticks and accuracies and there by reduce many litigations, being currently forced by user agencies based on ill-advised cartographic principles like enlargement of small scale maps beyond certain limits. Adoption of conversion parameters will help in deriving the type of ground accuracies expected in a CRZ map in future.

For better map preparation, Use Survey of India topo-sheets upto 1:25,000 and cadastral maps. Aerial photos and satellite data should be duly geo-referenced with Datum Conversion Parameters and ground control points should be cartographically adjusted keeping in view the accuracy requirement for planning purposes. Large scale maps, larger than 1:25,000 should be prepared using ground techniques. ALTM using laser systems by digital data collection as it will enable plotting on any scale, to be taken up as a National Project.

7. INTERPRETATIONS AND CONCLUSION :

The High Tide Line position mapping employ a variety of techniques since mid Eighteenth Century. The HTL data was collected as documented in the draft manual for delineation of the high water line prepared by the authorised agencies appointed by MoEF and instructions to US coast and geodetic surveys topographic field parties, to meet the requirement of MoEF notification on CRZ. Accordingly high tide line was determined by physical appearance of the beach and not by vertical tidal datum technique. Vertical tidal datum technique adopted by Survey of India in 1993 in the Goa region did not yield the satisfactory results as beach cyclicity (erosion and deposition) and wind driven wave data sets (specially during monsoon) were not available for the

study. It was noticed that, at many places, the actual HTL was >20 meters landward from the demarcated HTL during monsoon season. Therefore in such cases, what the demarcator actually delineated is the horizontal position of HTL, associated with wave run up at preceding high tides and forming geomorphic features like dune scarp, berm crest, tonal difference between wet and dry beach, below which the fore shore is smooth. In addition to above features boundary of perennial natural terrestrial vegetation, flotsam, drift wood was also considered. The identification of these markings enabled a reasonably accurate assessment of High Tide Line. , The designated CRZ boundary line of 200 meters was delineated parallel to HTL configuration uniformly along the coast by following standard principles.

Eventhough a number of DGPS survey equipments are available, as these can be used directly over the HTL marks to obtain the final co-ordinates, the task is not that easy. Fixing the HTL marks with the DGPS instrument may be easy and quick along the flat beaches but it is extremely difficult to use in rocky , sloppy and terrain areas, where carrying the DGPS equipment and the battery unit and cables is practically impossible. Of course, DGPS instrument can perform the most precise static surveying, but using this instrument for HTL identification, will take long, long time to complete the task. As mentioned earlier, after setting up the DGPS instrument on the base station, it requires observations of atleast four satellites for a period of about 60 minutes. The DGPS may miss the satellite signals, if the HTL falls along shadow zones. There is absolutely no check available for the collected positions on the HTL mark, whether correct or not, especially in shadow zones. But, all such problems are overcome in the delineation of HTL surveys, when Laser Trak instrument is used. All that is required to be carried along the HTL marks is a multi-prism fitted on a support rod, which weighs less than 5 kilos and can be carried easily over any type of terrain.

The best possible method suggested by the author for the delineation of HTL surveys is as follows:

- 1) All along the survey area, after properly identifying the suitable locations for establishing the base line stations, Trimble DGPS Series 4000 Receiver can be used for obtaining the base station co-ordinates (Geographical or UTM co-ordinates), with great precision, in static mode.
- 2) If required, using Wild T-2 Theodolite, the base line stations should be extended to any convenient locations, all along the survey area, by doing Triangulation surveys.

3) Once this Triangulation network is well established over the whole survey area, Laser Trak instrument should be set up over such stations, which has maximum possible coverage and visibility of the HTL marks. A demarcator walks along the HTL with a Multi-Prism fitted on a 3metre rod (or more length) and halting at carefully identified HTL marks for Laser Trak observation at specified intervals. The HTL survey can be commenced now by logging all the required raw data at specified intervals.

Using the above method, useful data collection from the coastal areas can be done to enable scientific bodies and Coastal Zone Regulation Authorities, to carry out studies, involving Coastal Zone Management, so that the scientific community can come out with innovative ideas and results, thereby protecting our valuable coastal zone from all hazards, in the future.

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REFERENCES

1. Srinivasan, K.R. 1998 Rear Admiral, Chief Hydrographer : Coastal regulation zone management:: Source from Internet web pages of Naval Hydrographic Office.



Fig :1 Figure shows “Laser Trak” an optical instrument mounted on a Tripod stand, used for measuring angles and distances from shore based locations.