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MANUAL OF PROCEDURES ON THE TRANSFORMATION AND INTEGRATION OF CADASTRAL DATA INTO THE PHILIPPINE REFERENCE SYSTEM OF 1992 (PRS92)

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Pursuant to Section 22 of the Department of Environment and Natural Resources (DENR) Administrative Order No. 2005-13 entitled "Revised Guidelines for the Implementation of the Philippine Reference System of 1992", this Manual is hereby issued for the guidance and compliance of all concerned.

SECTION 1. Objectives – This Manual is issued (a) to provide standards in converting and transforming cadastral data, surveys, and maps into PRS92, (b) to ensure spatial consistency in integrating these datasets to PRS92, preparation of Control/ Land Information Maps (projection maps), and utilization of these data by other users; and (c) to adopt basic database management practices to ensure quality, integrity and accessibility of datasets.

SECTION 2. Scope – This Manual shall cover the transformation and integration of all cadastral data to PRS92, and provide database management mechanisms covering the transformed datasets.

SECTION 3. Definition of Terms – The following terms used in this Manual shall be defined as follows:

a. Adjusted Coordinates – the resulting PRS92 coordinates after the application of the transformation parameters.
b. Analog data – traditional cadastral paper maps and records.
c. Cadastral data – records of cadastral and isolated surveys.
d. Cadastral database – a collection of logically related geo-referenced seamless digital vector data and raster data organized to facilitate data retrieval, exchange and integration, and a data model designed for all legal land objects managed by Land Management Bureau (LMB)/ Land Management Services (LMS) based on a survey of their boundaries. Such legal land objects are systematically identified by means of some separate designation and are defined by existing laws.
e. Cadastral map – a map made as a result of a Cadastral Survey, drawn to appropriate scale and showing all land parcels and important natural and man-made features within a municipality/project, for purposes of describing and recording ownership.
f. Cadastral survey projects – projects covering surveys of extensive areas covering an entire municipality or city consisting of several or many parcels of land undertaken for the purpose of title clearance and land registration.
g. Check points – control points used in assessing the accuracy of the transformation parameters derived.
h. Control Points – points whose coordinates are known, marked by a monument, and used as references for land surveys.
i. Conversion – the process of producing a digital version of an analog data.
j. Coordinate system – a fixed system of lines used to define the position of a point, line or plane.
k. Digital data – analog data recorded electronically that such storage and other operations can be made using computers.
l. Global Navigation Satellite System – a standard generic term for satellite navigation systems that provide autonomous geospatial positioning with global coverage.

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m. Graphical Cadastre – a cadastral survey wherein the bearings and distances of the individual lots are determined using transit and stadia, scaling from photo maps, and other graphical methods.
n. Integration – the process of transforming and consolidating data, surveys and maps into PRS92.
o. Local transformation parameters – numerical constants used in the transformation of local or area-based coordinates into PRS92.
p. Metadata – a structured data which describes the characteristics of a feature.
q. Numerical Cadastre – a cadastral survey wherein the bearings and distances of the individual lots are determined from the computations based on the actual ground survey.
r. Philippine Reference System of 1992 (PRS92) – the national common coordinate reference system for all surveys and maps pursuant to EO 45, series of 1993, as amended by EO 321 and EO 280, series of 2000 and 2004, respectively.
s. Residual – the difference between the observed and the computed coordinates based on the transformation parameters derived.
t. Source Map – the map outputs of a cadastral survey used in the conversion of existing cadastral data such as cadastral maps, and boundary index maps.
u. Transformation – the process of converting spatial datasets from one coordinate system to another.
v. WGS84 – an earth-centered, earth-fixed global reference frame for the Earth, currently the reference frame being used by the Satellite-based Positioning System (SPS), for use in geodesy and navigation.

SECTION 4. Cadastral Data Conversion – The transformation and integration of approved cadastral data shall follow the process flow shown in Annex A[*]. It shall start with the conversion of lot corners, survey project controls and other reference points. The data conversion of coordinates and maps is an initial step in the creation of the digital cadastral database.

The sources of data to be used in the conversion are as follows:

a. lot data computation sheets
b. lot description sheets
c. field notes
d. monument description books
e. monument recovery reports
f. municipal or boundary index maps
g. project control maps
h. traverse computation sheets
i. political boundary computation sheets
j. other relevant records

The conversion process shall be governed by the following order: (a) lot data computation sheets shall be the primary source of information for the cadastral lot data conversion, (b) in the absence of these, lot description sheets shall be used, (c) in the absence of the above, reconstruct the lot data computation and lot description sheets using the original field notes on file. (d) in case all of the above-mentioned sources of data are unavailable and after exerting all efforts thereon to retrieve from other sources, individual lots/parcels shall be resurveyed under the new reference system in accordance with the existing regulations thereof.

4.1 Inventory of Records – A comprehensive physical inventory of cadastral records shall first be conducted by the regional land sector offices in order to assess the completeness and quality of the records and facilitate the integration of these datasets into PRS92. The results of the inventory shall be reported following the format shown in Annex B.1[*] to B.3[*]

4.2 Conversion of Coordinates – The coordinates to be used in the transformation shall be in Philippine Plane Coordinate System – Transverse Mercator / Luzon 1911 (PPCS- TM/ Luzon 1911) coordinates. Coordinates

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based on the Local Plane Coordinate System (LPCS) shall be converted to PPCS-TM/Luzon 1911 using the procedures prescribed by the Land Management Bureau (LMB) for conversion between the two coordinate systems.

4.2.1 Project Controls and Reference Points – Using the keyboard, encode the PPCS-TM/Luzon 1911 or LPCS coordinates (Northings and Eastings) of project controls or reference points using the customized Geodetic Network Information System (GNIS) or other spreadsheet or database templates developed for the purpose (see Annex C[*] for the sample database template)

4.2.2 Individual Lots/Parcels – The Northings and Eastings coordinates in PPCS-TM/Luzon 1911 of lot corners including the corresponding tie point shall be encoded through keyboard entry using the customized Land Survey Data Management System (LSDMS) or other spreadsheet or database templates developed for the purpose (see Annexes D[*] and E[*] for the sample templates, respectively). The bearings and distances as computed from the encoded lot corner coordinates shall be checked with the technical descriptions indicated in the lot data computation sheets (LMB Form No. GSD-B-9A)

4.3 Conversion of Bearings and Distances – In the absence of lot data computation sheets, lot description sheets containing the bearings and distances of all lines of boundary surveys and individual parcels shall be used as reference for the data conversion.

4.3.1 Project Controls and Reference Points – Encode the bearings and distances of the project controls or reference points using the customized GNIS or other spreadsheet or database templates developed for the purpose.

4.3.2 Individual Lots/Parcels – The bearings and distances of all lines in the lot, including the corresponding tie line, shall be encoded through keyboard entry using the customized LSDMS or other spreadsheet or database templates developed for the purpose. The coordinates of the individual lot corners shall be computed based on the technical descriptions of the lot (see Annex F[*] for the sample spreadsheet template.)

4.4 Reconstruction of Lot Data Computation and Lot Description Sheets Using Original Field Notes On File - In the absence of lot data computation and lot description sheets, and in case the original field notes of the cadastral survey is still available on file, lot data computation and lot description sheets shall be reconstructed using the prescribed procedures and computations.

4.5 Resurvey – A resurvey shall be conducted for lots with unavailable or missing records. The resurvey shall only be conducted after all efforts in researching data from other sources such as the Register of Deeds/Land Registration Authority (LRA), local government units (LGUs)/Assessor's Office, Court and other agencies or individuals, have been exerted and the affected lot is not titled/decreed. The new survey shall already be PRS92-compliant and shall no longer be transformed using the local transformation parameters.

4.6 Conversion of Graphical Cadastres (Cadastral Mapping) – Lot data computation for cadastral survey projects under the graphical cadastre system shall be generated after a resurvey of the affected lots have been conducted. The new survey shall already be PRS92-compliant and referenced to existing PRS92 control points. The lot data computation shall be converted for incorporation into the digital cadastral database.

4.7 Standardization of Data Conversion – To ensure uniformity and compatibility of converted data using different templates, the conversion shall follow the basic conventions set in Annex G[*] for the encoding of cadastral records.

4.8 Quality Control for Data Conversion – Quality control measures shall be implemented by the regional offices to ensure the integrity of the cadastral data to be converted.

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Errors observed in any of the data or records mentioned in Section 4, Paragraph 2 shall be properly noted for future technical/legal remedy.

In case of discrepancies in untitled/undecreed parcels /lots, correction shall be made by the Lands Management Services of the regional office concerned.

In case the discrepancy involves titled/decreed parcels/lots, corrections shall be made through court proceedings in accordance with the existing guidelines and procedures by the Lands Management Bureau.

4.9 Adoption and Approval of Coordinates from Converted Cadastral Data – The coordinates of individual parcels derived from the converted cadastral data, shall be adopted as official lot data computation and shall be incorporated into the cadastral database.

Any discrepancy observed between the original and the converted cadastral data shall be noted for future technical/legal remedy.

4.10 Plotting and Projection – Using the encoded or computed coordinates, project controls and reference points, as well as individual lot parcels per cadastral case of the city or municipality shall be plotted and projected using appropriate Computer-Aided Design (CAD) or Geographic Information System (GIS) software. The resulting digital graphics shall be consolidated to form digital cadastral and index maps.

4.11 Setting up of the Digital Cadastral Database – A digital cadastral database containing the converted coordinates, bearings and distances shall be set up and maintained for easy access and retrieval. The database shall also include any available descriptions, sketches, and remarks pertaining to the boundary monuments and parcels of lots.

Cadastral, boundary index and other maps on record shall also be converted and incorporated into the database for reference purposes. The conversion of maps shall follow the prescribed guidelines and procedures.

SECTION 5. Recovery and Observation of Existing Control Points - Records mentioned in Section 4 Paragraph 2 shall be used as reference in the recovery and observation process.

5.1 Recovery of Existing Project Control and Reference Points – The Composite Survey Teams (CSTs) shall undertake the reconnaissance and recovery of all existing control and reference points. An additional six (6) points per adjoining municipality/ cadastral survey project shall be recovered in order to tie the local transformation parameters to its adjoining areas. The six points shall be located near the common boundary of the adjoining municipalities/cadastral survey projects.

Recovered points shall be preserved and maintained for use in subsequent surveys and in the process of transforming other environment and natural resources (ENR) datasets to PRS92.

A monument recovery report with the corresponding monument recovery sheets of all the reference monuments and the project control scheme shall be submitted by the CSTs to the Chief of the Regional Surveys Division for evaluation and reference purposes. The monument recovery sheet and project control scheme to be attached in the report shall follow the templates shown in Annex H[*] and I[*], respectively.

5.2 Selection of Recovered Points for GPS Observation – Using the monument recovery report and project control scheme as reference, the CST shall select a sufficient number of recovered points for GPS observation. The selection of points shall comply with the following criteria set for the determination of transformation parameters:

> a. Recovered control points to be used in the determination of local transformation parameters shall be well-distributed over the whole project area. Otherwise, additional control points shall be established to satisfy

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this criterion. The newly established control points shall be referred to the old coordinate system.

b. Recovered control points that are disturbed shall not be used in the transformation. Control points that are found to be intact but do not satisfy the requirements for a GNSS survey shall be observed by establishing a baseline between two PRS92 control points nearest the recovered control point of interest, and taking a side shot on this point.

c. In case there is an insufficient number of existing project control and reference points recovered by the CSTs, the coordinates of corner monuments of titled parcels of lots shall be used in the determination of the transformation parameters. These lot corners must be stable and with minimum obstruction. The CSTs shall conduct a verification survey to access the accuracy of the lot corners.

The Chief of the CST shall submit the list of recovered points for GPS observation to the Chief of the Regional Surveys Division for approval.

5.3 Observation of Existing Reference Monuments – PRS92 coordinates of the selected recovered reference monuments shall be derived through GNSS survey or conventional techniques.

Factors relevant to the conduct of a GNSS survey, such as network observation design, availability of reference points, accessibility, survey methodology and suitable GNSS receivers, shall be considered by the CST.

5.3.1 Persons Authorized to Conduct the GNSS Surveys – the GNSS surveys shall be undertaken by persons authorized in accordance with RA 8560, as amended by RA 9200, otherwise known as “The Geodetic Engineering Act”, who are knowledgeable in GNSS surveys.

5.3.2 Survey Methodology – The survey shall be undertaken using either of the techniques described below;
a. GNSS Technique – The project controls and other reference points shall be surveyed using either static or fast static technique, referenced to two (2) existing PRS92 control stations of at least third (3rd) order accuracy (1:20000). The conduct of the survey shall be in accordance with Sections 51-59 of DAO 98-12 (Revised Manual of Land Surveying Regulations in the Philippines).

b. Conventional Technique – In case there are no available GNSS equipment, theodolites with Electronic Distance Meter or Total Stations may be used in determining the position of control point. The survey must be tied or referred to existing PRS92 control points. The procedures shall be consistent with the relevant provisions of DAO 98-12.

5.4 Preparation and Submission of Field Survey Report – Upon completion of the field survey, the CST shall submit a report to the RTD for Lands through the Regional Surveys Division Chief. The report shall include the following:

a. Status of all reference monuments with the corresponding project control scheme.

b. Monument recovery sheets following the format shown in Annex H indicating the description, name and number, geographic coordinates physical status, location, photograph, sketch, access and other relevant information of the recovered monument.

c. Narrative report of the field survey conducted, including the methodology of observation, instruments used , obstruction diagram at the time of observation, and other relevant information.

5.5 Approval of the Selections of the Project Control Points for Transformation – The Chief of the Regional Surveys Division shall evaluate and approve the selection of control points and reference monuments to be used in the determination of transformation parameters.

SECTION 6. Transformation - The local transformation parameters shall be determined by the LMS concerned on

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a cadastral survey basis for each city or municipality.

The old PTM and PRS92 grid coordinates of the recovered control points shall be used in the determination and accuracy assessment of the local transformation parameters. A minimum of two check points shall be set aside for testing the accuracy of the transformation and shall not be used in the determination of parameters.

6.1 Determination of Transformation Parameters – The process of determining the transformation parameters involves the following steps.

6.1.1 Using a spreadsheet template, encode the new grid coordinates of the recovered points

6.1.2 Compute the local transformation parameters using the four-parameters transformation procedures. The transformation involves rotation, scaling and translation therefore preserving the shape of the feature being transformed.

The solution for the four-parameter transformation is a linear conformal transformation with shift. It is based on the mathematical model provided below:

A * X + B * Y + CE = E

-B * X + A * Y + CN = N

where: A and B = scale and rotation constants
CE and CN = shift constants

X and Y = PPCS-TM/Luzon 1911 coordinates

E and N = PPCS-TM/PRS92 coordinates

Each of the recovered control points will have both old PTM and PRS92 grid coordinates. The parameters A, B, CE and CN are the solutions to the set of equations formed. The linear equations can be solved using the method of least squares (see Annexes K[*] and L[*] for the sample solution using spreadsheet and database templates, respectively).

Weights shall be applied in case the transformation points are a combination of reference monuments, project control points, and lot corners. The weights shall correspond to the level of accuracy by which these points were observed. Thus, the weights to be applied shall be as follows:

Reference Monuments = 4
Project Control Points = 2
Lot Corners = 0.5

6.1.3 Analysis of Results – A comparison between the old PRS92 grid coordinates is made to assess the accuracy of the transformation. The steps are as follows:

6.1.3.1 Compute the residual error (VE , VN) at each point:
VE , VN = PRS92 GNSS Observed - PRS92 Adjusted Coordinate

6.1.3.2 Check if the PRS92 GNSS Observed coordinates are correctly measured by calculating the standard deviation in position, mp.

(See Image (NAR) VOL. 21 NO. 1/ JANUARY - MARCH 2010 page 183)

where 2(n - 2) represents the number of redundant equations.

6.1.3.3 Analyze points with large residual errors. Points with residual errors exceeding 1.0 m should not be used

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in the derivation of the transformation parameters.

6.1.3.4 Solve for the new transformation parameters using the remaining control points. The remaining control points to be used in solving for the new transformation parameters must still satisfy the geometric conditions, i.e., the control points are well distributed over the project area.

6.1.3.5 Repeat the above steps until no significant residual error is computed and the standard deviation is within the allowable limit.

6.2 Assessment of Transformation Accuracy – The accuracy of the transformation shall be evaluated by NAMRIA, in collaboration with LMB. The assessment procedure shall include, but not limited to, the following steps:

6.4.1 Preliminary Accuracy Checking – The distribution and number of control points used in the determination of transformation parameters shall be assessed using the project control scheme submitted.

6.4.2 Ground Validation of Transformation Parameters Using Check Points – Check points shall be transformed into PRS92 using the local transformation parameters derived. These check points shall be validated through a ground survey in order to assess the fit of the transformation parameters.

6.4.3 Verification of Adjoining Cadastral Projects – Selected lots located along the common boundary of adjoining municipalities/cadastral survey projects shall be transformed into PRS92 using the transformation parameters derived. A minimum of ten (10) transformed and undisturbed lot corners shall be validated through ground survey to check the consistency of the transformation between two adjoining municipalities.

In case of discrepancy, a review of the transformation procedure shall be conducted, from checking the accuracy of the original data, to the recovery and observation of reference monuments, and the determination of transformation parameters. Non-uniform/non-homogeneous residuals/distortions indicate possible erroneous cadastral survey. A resurvey of the whole cadastral survey project shall be conducted in case an erroneous survey has been verified.

6.3 Derivation of PRS92 coordinates. – The transformation parameters computed from the preceding steps will be used to solve for the PRS92 coordinates of all other control points in the area. The same mathematical model in Section 7.1.2 shall be used to compute for the PRS92 coordinates:

$$A * X + B * Y + CE = E$$

$$-B * X + A * Y + CN = N$$

In this case, the parameters A, B, CE , and CN are already known. X and Y are the PPCS-TM/Luzon 1911 grid coordinates. E and N are the PRS92 Easting and Northing, respectively (see Annexes L[*] and M[*] for the sample solution using spreadsheet and database templates, respectively).

6.4 Verification and Approval – The Regional Technical Director for Lands shall recomend approval of the derived parameters to the Land Management Bureau (LMB). The following shall be submitted for proper assessment:

a. Field Survey Reports, including the documents mentioned in Section 5.3.1
b. All computation files generated, both in soft and hardcopy, in the determination of the local transformation parameters
c. Approved scheme showing the selected project controls and reference monuments recovered and observed for the derivation of transformation parameters.
d. Raw data of GPS observation conducted

The NAMRIA and LMB shall implement appropriate mechanisms for the approval of the parameters either through control or reference points database build-up or other acceptable measures or strategies.

SECTION 7. Integration – The transformed PRS92 coordinates of reference points projects controls, and individual lots/parcels shall be used to produce a control map in PRS92.

7.1 Plotting and Projection to PRS92 Control Map – The visualization and analysis of the results of the transformation procedures can be made by plotting the results digitally using appropriate mapping software.
For cadastral survey controls, transform the coordinates of the control points into PRS 92 using the parameters derived in Section 9. The transformed coordinates shall then be plotted using CAD software.

For parcellary surveys, integrate the data into PRS92 by transforming the tie point coordinates using the parameters derived from Section 7. The coordinates of corner points are transformed using the lot data computation program (as shown in Annexes D[*] and E[*]).

7.1.1 Plot adjacent parcels using the PRS92 coordinates to produce a cadastral map in PRS92.
7.1.2 Compare the PRS92 cadastral map with the existing cadastral maps to verify the accuracy of the transformation.
7.1.3 In cases where the transformed parcellary surveys with computed technical descriptions are not consistent with the declared technical descriptions, a report shall be submitted to the Regional Surveys Division Chief for proper evaluation and rectification based on existing policies and guidelines.
7.1.4 The Regional Surveys Division Chief shall evaluate and recommend for approval by the Regional Technical Director for Lands the transformation to ensure quality control.

7.2 Database Build-up – The cadastral database discussed herein refers only to the data/documents managed by LMB/LMS. For purposes of this Manual, however, it shall be limited to the data mentioned in Section 4, Paragraph 2.

In addition to the data creation processes mentioned in the preceding sections, the following database management procedures shall be observed:

a. Loading and merging of transformed project datasets to the cadastral database.
b. Periodic dataset and database back-up
c. Database and dataset restoration, as necessary
d. User account management.
e. Database performance tuning

The national and regional cadastral database shall be managed by LMB and LMS, respectively. LMS shall provide periodic postings to LMB in order to update the national cadastral database.

NAMRIA, being the central data repository agency, shall be provided periodically a copy of the national cadastral database by LMB. It shall also extend technical assistance in the maintenance of the cadastral database management system in LMB and LMS.

The LMB/LMS shall issue specific guidelines for the management of the cadastral database in consonance with the procedures and standards herein specified.

7.3 Updating for New Surveys – New cadastral and isolated surveys conducted after the transformation shall already be PRS92-compliant. The LMB shall provide the guidelines for the conduct of inspection, verification and approval of surveys in PRS92. Lot data computation and other relevant records shall be incorporated into the digital cadastral database.

Cadastral data that has already been converted may be incorporated into the cadastral database, subject to the

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evaluation by the regional surveys division chief.

SECTION 8. Software Programs for Transformation and Integration – The NAMRIA shall provide the CSTs with the following templates:

8.1 Analog to digital conversion of bearings, distances, coordinates, and other technical descriptions of individual lots or parcels using spreadsheet and database;

8.2 Analog to digital conversion of all cadastral monument coordinates for each city or municipality using the four (4) local transformation parameters using spreadsheet and database; and

8.3 Derivation of four (4) local transformation parameters for each city or municipality using spreadsheet and database.

SECTION 9. Metadata and the Cadastral Spatial Data Infrastructure – NAMRIA shall design and develop a Metadatabase System for the cadastral survey data and shall be installed in the LMS regional offices. Training on the use and management of said system shall be conducted by NAMRIA for the regional CSTs.

The metadata of cadastral survey data shall provide the basis towards the creation of a Cadastral Spatial Data Infrastructure (CSDA).

SECTION 10. Unauthorized Copying and Transfer of Cadastral Datasets Generated– Copying and/or transfer of cadastral data generated under this Manual without proper authority shall be dealt with under applicable laws, rules and regulations, and will be meted with appropriate penalties.

SECTION 11. Subcontracting/Outsourcing of Data Conversion – Subject to existing rules and regulations, the Regional LMS offices may opt to contract out or outsource the data conversion and survey provided the current LMS staff cannot accommodate the said activity, and the cost shall not exceed the prevailing unit cost.

SECTION 12. Transfer of Data from LMB to LMS – The LMB shall inventory all the cadastral data in their custody and shall subsequently transfer these data into the respective LMS offices for conversion and transformation into PRS92. These data shall include the records cited in Section 4, Paragraph 2 as well as data stored in other media such as microfilms and magnetic disks/tapes.

SECTION 13. Technical Assistance to the LMS by NAMRIA and LMB – The NAMRIA and LMB shall continue to oversee and provide technical assistance to the LMS on the conversion and transformation of surveys and maps into PRS92. The process, a graphics database shall be developed to support the determination and approval of local and national transformation parameters.

SECTION 14. Creation of Task Groups – The NAMRIA and LMB shall create a Task Groups, mobile resources, monitor the implementation, and extend technical assistance in the process of conversion and transformation to enhance the attainment of the objectives of this Program.

SECTION 15. Penalty Clause – Any violation or non-compliance of the provisions of this Manual shall be meted with appropriate penalties subject to existing laws, rules and regulations.

SECTION 16. Supplementary and Amendatory Procedures – Supplementary procedures/amendments to this Manual shall be issued jointly by the NAMRIA Administrator and the LMB Director.

SECTION 17. Repealing Clause – All procedures inconsistent with this Manual are hereby repealed or modified accordingly.

SECTION 18. Effectivity – This Manual shall be adopted immediately.

Adopted: 04 Feb. 2010

(SGD) ELEAZAR P. QUINTO
Secretary

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[*] Text Available at Office of the National Administrative Register, U.P. Law Complex, Diliman, Quezon City

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