JOINT BASE LEWIS-MCCHORD
STORMWATER MANAGEMENT FOR
DEVELOPMENT AND REDEVELOPMENT

Prepared by:
Public Works Environmental Division
2012 Liggett Ave
Joint Base Lewis-McChord, Washington 98433

May 2017

This page intentionally left blank

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDICES

LIST OF ACRONYMS

ADT	Average Daily Traffic
AADT	Annual Average Daily Traffic
AOA	Aircraft Operations Area
Aviation Manual	Aviation Stormwater Design Manual
BMPs	Best Management Practices
Ecology	Washington State Department of Ecology
EISA	Energy Independence and Security Act
EPA	Environmental Protection Agency
GIS	Geographic Information System
JBLM	Joint Base Lewis-McChord
LID	Low Impact Development
LIDM	Low Impact Development Technical Guidance Manual for the Puget Sound
MS4	Municipal Separate Storm Sewer System
NPDES	National Pollutant Discharge Elimination System
NPGIS	Non pollutant generating imperious surface.
PGPS	Pollution generating pervious surfaces
RCW	Revised Code of Washington
SWM	Stormwater Management Manual for Western Washington (2012 Ed)
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
UIC	Underground Injection Control
WAC	Washington Administrative Code
WWHM	Western Washington Hydrology Manual
WSDOT	Washington State Department of Transportation

JOINT BASE LEWIS-MCCHORD
STORMWATER MANAGEMENT FOR DEVELOPMENT AND REDEVELOPMENT

1. PURPOSE

This stormwater management document provides a step-by-step process that will assist designers in meeting the requirements of Joint Base Lewis-McChord's (JBLM) Municipal Separate Storm Sewer System (MS4) Permit No. WAS-026638 (U.S. Environmental Protection Agency, 2014). The Permit requires stormwater management for development or redevelopment to be consistent with portions of the Stormwater Management Manual for Western Washington (**SWM**, Washington State Department of Ecology, 2012). JBLM's objective is to manage stormwater from developed areas, new development and redevelopment project sites in a manner that maintains the site's predevelopment runoff conditions and prevents or minimizes water quality impacts, preserves and restores the area's predevelopment hydrology. Specifically, JBLM and its contractors will manage stormwater runoff from all public and private new development or redevelopment project sites to the extent feasible

2. SITE PLANNING PROCESS

a. **General**. A site specific Stormwater Drainage Plan shall be developed by the designer for new development and redevelopment project sites disturbing more than 5,000 square feet. . Stormwater drainage plans must be prepared consistent with Chapter 3, Volume 1-Minimum Technical Requirements and Site Planning of the SWM and with Chapter 3 of the Low Impact Development Technical Guidance Manual for the Puget Sound (Hinman and Wulkan, 2012) referred to as the **LIDM** and the Army Low Impact Development Technical Guidance (U.S. Army, 2013).

b. Stormwater management for development and redevelopment projects disturbing MORE than 5,000 square feet will consist of the following steps:

(1) Preparation of Stormwater Drainage Plan

(2) Submittal of Plan to JBLM Stormwater Program for review

(3) Approval of the Plan prior to construction activities

c. Horizontal projects that disturb LESS than 5,000 square feet but will change final grades shall include erosion control measures in the site Environmental Protection Plan. The following information shall be provided:

(1) A site plan layout,

(2) A map showing drainage paths, and

(3) A list of Best Management Practices (BMPs) utilized to control runoff.

d. **Airport Operations Area**. For new development or redevelopment sites disturbing 5,000 square feet or more within Airport Operations Areas (AOA), stormwater drainage plans must be prepared consistent with the Aviation Stormwater Design Manual (Washington State

Department of Transportation, 2008), referred to as the **Aviation Manual**. An AOA is defined as any area of an airport used or intended to be used for landing, takeoff, or surface maneuvering of aircraft. This includes such paved or unpaved areas that are used or intended to be used for the unobstructed movement of aircraft in addition to associated runways, taxiways, or aprons. AOAs for McChord and Gray Army Airfields are shown in **Figures 1 and 2**.

e. **Regulatory Agency.** JBLM is a federal installation and is under the jurisdiction of EPA rather than the State of Washington for stormwater management. Therefore, all criteria of the SWM may not apply. References to State Permits in the SWM should be replaced with EPA Permits, as required. Similarly, any references to contacting the State should be replaced with the JBLM Stormwater Program. For guidance or further clarification contact the JBLM Stormwater Program at: usarmy.jblm.imcom.list.dpw-stormwater@mail.mil.

f. **Exemptions**. Types of projects exempted from all or part of the development/redevelopment requirements are listed in Appendix A.

3. STORMWATER DRAINAGE PLAN

a. **General.** A Stormwater Drainage Plan shall be prepared that describes the measures that will be implemented to manage stormwater runoff from the development/redevelopment site. Content of the Stormwater Drainage Plan is described in the following sections and is shown in **Figures 3 through 6**.

b. **Checklist.** A checklist to assist in drainage plan preparation and compliance with JBLM's permit is included in Appendix B. Designers are encouraged to use the checklist when preparing the Stormwater Drainage Plan.

c. **Stormwater Drainage Plan components.** The stormwater drainage plan is subdivided into nine different sections outlined as follows:

(1) **Project Overview and Existing Conditions (SWM Vol. I Chap. 3 Steps 1-4 – Minimum Requirement #1)** Volume 1, Section 3.1.1 of the SWM describes the information required in the site overview and existing conditions section. Modifications to the requirements of this section of the SWM are listed below.

(a) **Site Layout.** A site layout showing property lines and existing structures and conditions shall be prepared by a qualified professional. Unlike a municipality or other local government, all property on JBLM is federally owned. Therefore, a registered land surveyor is not needed to establish ownership or boundaries of property that is to be developed or redeveloped except where the project site borders the installation boundaries. However, care shall be taken by the professional designer to ensure that site boundaries, buildings, utilities, appurtenances, and improvements are accurately shown on maps and drawings. Accurate basemaps for the installation in Geographic Information System (GIS) format are available from the Directorate of Public Works Geospatial Office, located on Lewis-Main in the basement of Building 2012.

(b) **Geotechnical Report.** A geotechnical report containing information about underlying soils, infiltration test results, and evaluation of any hydraulic restrictions underlying the site shall be included. It is the designer's responsibility to ensure that the soil types of the site are properly identified and correctly used in the hydrologic analysis. If infiltration data is not collected during the design process, infiltration testing may be conducted during construction to confirm assumptions made during design. NOTE: If collecting infiltration data is postponed until construction, the designer/government risks potential contract changes if conditions are not suitable for adequate infiltration.

(2) **Permanent Stormwater Control (SWM Vol. I Chap. 3 - Step 5).** Provisions for permanent stormwater control shall be prepared consistent with Volume 1 - Chapter 3 of the SWM and Chapter 3 of the LIDM. Required components are described in the following sections. Corresponding sections of the SWM are in shown parenthesis.

(3) **Source Control of Pollution – (SWM Vol. I Chap. 2 -Minimum Requirement #3) See Figure 3** All new development and redevelopment project sites disturbing 5,000 square feet or more shall utilize available and reasonable source control BMPs. Source control BMPs must be selected and designed consistent with Volume IV of the SWM. For construction sites see Vol. II, Chap. 4. For new development or redevelopment sites disturbing 5,000 square feet or more within AOA, source control BMPs must be selected and designed in consistent with the Aviation Manual. Information about physical BMPs shall be provided in a Table with the following information:

(a) Type of BMP (e.g. swale, infiltration trench, etc),

(b) Survey coordinates in Universal Transverse Mercator (UTM) 1983 datum,

(c) If applicable, area in square feet serviced by the BMP, and

(d) Approximate cost of BMP including installation

(4) **New Development and Redevelopment Site Design to Minimize Impervious Areas, Preserve Vegetation, and Preserve Natural Drainage Systems (SWM Vol. I Chap. 2 -Minimum Requirement #4). See Figure 3**. All new development and redevelopment project sites disturbing 5,000 square feet or more shall be designed to minimize impervious surfaces, retain vegetation, restore native vegetation, and preserve natural drainage systems, considering the techniques in the SWM, and meet the following requirements to the extent feasible:

(a) Site design shall be developed that minimizes the project's roadway surfaces and parking areas, incorporates clustered development, and ensures that vegetated areas receive stormwater dispersion from all developed project areas;

(b) Natural drainage patterns of the project site shall be maintained, and discharge from the new development or redevelopment project site occurs at the natural location;

(c) The manner by which runoff is discharged from the new development project site does not cause a significant adverse impact to downstream receiving waters and/or down gradient properties; and

(d) All outfalls shall utilize dissipation devices.

(5) **Hydrologic Performance Requirement for On-site Stormwater Management (SWM Vol. I Chap. 2 - Minimum Requirement #5). See Figure 4.** For all new development or redevelopment project sites disturbing 5,000 square feet or more, on-site stormwater management practices intended to infiltrate, disperse, retain, and/or harvest and reuse stormwater runoff shall be used as follows:

(a) Lawn and landscape areas on the new development or redevelopment project sites. Soil quality shall meet the specifications of BMP T5.13 (Post Construction Soil Quality and Depth) in SWM Vol. V Chap. 5. Lawn and landscape areas associated with project sites within the AOAs must meet the soil quality specifications of the Aviation Manual.

(b) New or redevelopment project sites creating or replacing 2,000 > 4,999 square feet of hard surfaces. To the extent feasible, stormwater dispersion or infiltration BMPs will be used consistent with SWM Vol. V Chap. 5; Sections 3.1, 3.3, and 3.4 of Chap. 3 of Vol. III of the SWM; and/or the LIDM. Project sites within AOAs must ensure that stormwater dispersion or infiltration BMPs are used consistent with those specified in the Aviation Manual.

(c) New development or redevelopment project sites creating or replacing 5,000 square feet or more of hard surfaces. Sites must meet one of the three conditions below.

(i) The post-development stormwater discharge flows from the project site shall not exceed the pre-development discharge flows for the range of 8% of the 2-year peak flow to 50% of the 2-year peak flow, as calculated by using the Western Washington Hydrology Model (**WWHM**, Clear Creek Solutions, 2014), or other continuous runoff model. The modeled pre-development condition for all new development and redevelopment project sites must be "forested land cover" (with applicable soil and soil grade), unless reasonable historic information indicates the site was prairie prior to settlement (and may be modeled as "pasture"). Summary sheets of the output from the computer model shall be included in the Drainage Plan. OR

(ii) Controls for post-development discharge flows shall meet the requirements of List #2 of Minimum Requirement #5 in Volume 1 of the SWM. See Appendix C. OR

(iii) Alternatively, stormwater controls may be designed to retain on-site the volume of stormwater produced from the 95th percentile rainfall event. JBLM may exempt a project site from retaining the total runoff from the 95% rainfall event, provided compliance is documented. Feasibility must be determined by evaluating design criteria, limitations and infeasibility for each BMP in the SWM beginning with the List and the competing needs described in Appendix C.

(d) If the above conditions cannot reasonably be met, the proponent may propose that the project be exempted. Proposed infeasibility exemptions will be reviewed and approved by the Public Works Director or authorized individual. The proposal shall the following information:

(i) Name, location and identifying project description;

(ii) Reasons why full retention of the total volume of runoff calculated to meet the 95^{th} % rainfall event is not feasible, including supporting documentation and all relevant engineering calculations, geologic reports, and/or hydrologic analysis; and

(iii) The estimated annual runoff volume that can be managed on site and the remaining annual runoff volume for which it is deemed not feasible to manage onsite.

(6) **Hydrologic Performance Requirement for Flow Control (SWM Vol. I Chap. 2 - Minimum Requirement #7). See Figure 5**.

(a) New development and redevelopment project sites shall be designed to control post development discharge flows where such sites:

(i) Create >10,000 square feet effective impervious surface area;

(ii) Convert ¾ acres or more from native vegetation to lawn/landscaping, and from which there is a surface discharge to a natural or manmade conveyance system; and/or,

(iii) Convert 2.5 acres or more of native vegetation to pasture, and from which there is a surface discharge to a natural or manmade conveyance system.

(b) For these new development or redevelopment project sites, post-development stormwater discharge flows must not exceed the pre-development discharge flows for the range of 50% of the 2-year peak flow to 100% of the 50-year peak flow, as calculated by using the Hydrology Model (or other continuous runoff model).

(c) When using the Hydrology Model, the pre-development condition for all new development and redevelopment project sites must be "forested land cover" (with applicable soil and soil grade), unless reasonable historic information indicates the site was prairie prior to settlement (and may be modeled as "pasture").

(d) Small scale dispersion or infiltration practices, or other appropriate LID practices shall be prioritized to meet this flow control requirement. New development or redevelopment sites may not meet this hydrologic performance requirement for flow control solely through the use of large scale retention or detention practices.

(e) New development or redevelopment project sites that will discharge directly to the JBLM Canal, or indirectly through Outfalls L004 or L005, are exempt from this hydrologic performance requirement for flow control.

(f) JBLM may exempt a project site from full compliance with the performance standards cited above if the severe economic cost criteria referenced in Appendix A prevent use of certain BMPs to attain the performance standards. In such instances, the designer shall manage as much of the calculated flow volume as possible.

(7) **Runoff Treatment (SWM Vol. I Chap. 2 - Minimum Requirement #6). See Figure 6.** Facilities for runoff treatment shall be constructed in accordance with Appendix D. Stormwater treatment facilities for all new development or redevelopment sites shall be constructed for projects in which:

(a) The total area of pollution-generating hard surface (PGHS) is 5,000 square feet or more, or

(b) The total area of pollution-generating pervious surfaces (PGPS), exclusive of permeable pavements, is 3/4 of an acre or more; and from which there will be a surface discharge in a natural or man-made conveyance system from the site.

(8) **Wetlands Protection (SWM Vol. I Chap. 2 - Minimum Requirement #8)** New development or redevelopment projects will ensure that discharges to wetlands from sites maintain the hydrologic conditions, hydrophilic vegetation, and substrate characteristics necessary to support existing and designated uses. A hydrologic analysis will be conducted that uses the existing land cover condition to determine the existing hydrologic conditions, unless directed otherwise by the JBLM Water Systems Manager or the Stormwater Program Manager.

(9) **Operation and Maintenance Manual (SWM Vol. I Chap. 2 - Minimum Requirement #9).** An operation and maintenance manual shall be prepared for permanent stormwater facilities that require maintenance. A draft manual shall be submitted to the Stormwater Program once the project has reached 100% design and/or prior to construction. A final manual shall be submitted with project close-out documents. The manual shall include but is not limited to the following:

(a) Plans or map showing the facility construction with accurate dimensions,
A description of the operation of the facility and maintenance associated with its operation,
Maintenance schedule,

(b) A list of materials or special equipment required for the facility operation and maintenance.

(10) **Underground Injection Control (UIC).** Runoff from a site that discharges to the subsurface may require registration or permitting under the Underground Injection Control Program (Ecology, 2008).

(a) In general, the following structures are considered Class V wells and require registration:

(i) Drywell,
(ii) Infiltration trench with perforated pipe (See Tables 1 and 2 for requirements),
(iii) Storm chamber systems,
(iv) Geoprobes or push probes,
(v) Any structure deeper than the widest surface dimension.

(b) Class V - UIC wells may not receive stormwater from the following areas:

(i) Vehicle maintenance, repair and service.
(ii) Commercial or fleet vehicle washing.
(iii) Airport de-icing activities.
(iv) Storage of treated lumber.
(v) Storage or handling of hazardous materials.
(vi) Generation, storage, transfer, treatment or disposal of hazardous wastes.
(vii) Handling of radioactive materials.
(viii) Recycling facilities, except for those that recycle only glass, paper, plastic, or cardboard.

(c) Appendix E contains a description of structures considered as Class V wells. Class V wells must either be rule-authorized or covered by a state waste discharge permit to operate. If a Class V well is rule-authorized, a permit is not required, but must be registered. Registration

will be completed by the JBLM Stormwater Program. Designers should contact Stormwater Program staff to determine what information is required to fulfill the registration requirements. If a UIC well requires a treatment BMP for rule authorization, the BMP must be constructed an in accordance with Volume III or IV of the SWM. Complete guidance may be obtained from Ecology's Guidance for UIC Wells that Manage Stormwater (Ecology, 2006) provided in Appendix E.

d. **Special Reports and Studies.** Include any special reports and studies conducted to prepare the Stormwater Drainage Plan (e.g., a soils report that could include the results of soil sampling and testing, infiltration tests and/or soil gradation analyses, depth to ground water; wetlands delineation).

e. **Other Permits.** Include a list of other necessary permits and approvals as required by regulatory agencies other than JBLM (e.g. EPA Construction General Permit) if those permits or approvals include conditions that affect the drainage plan, or contain more restrictive drainage-related requirements.

4. SUBMITTALS AND COORDINATION

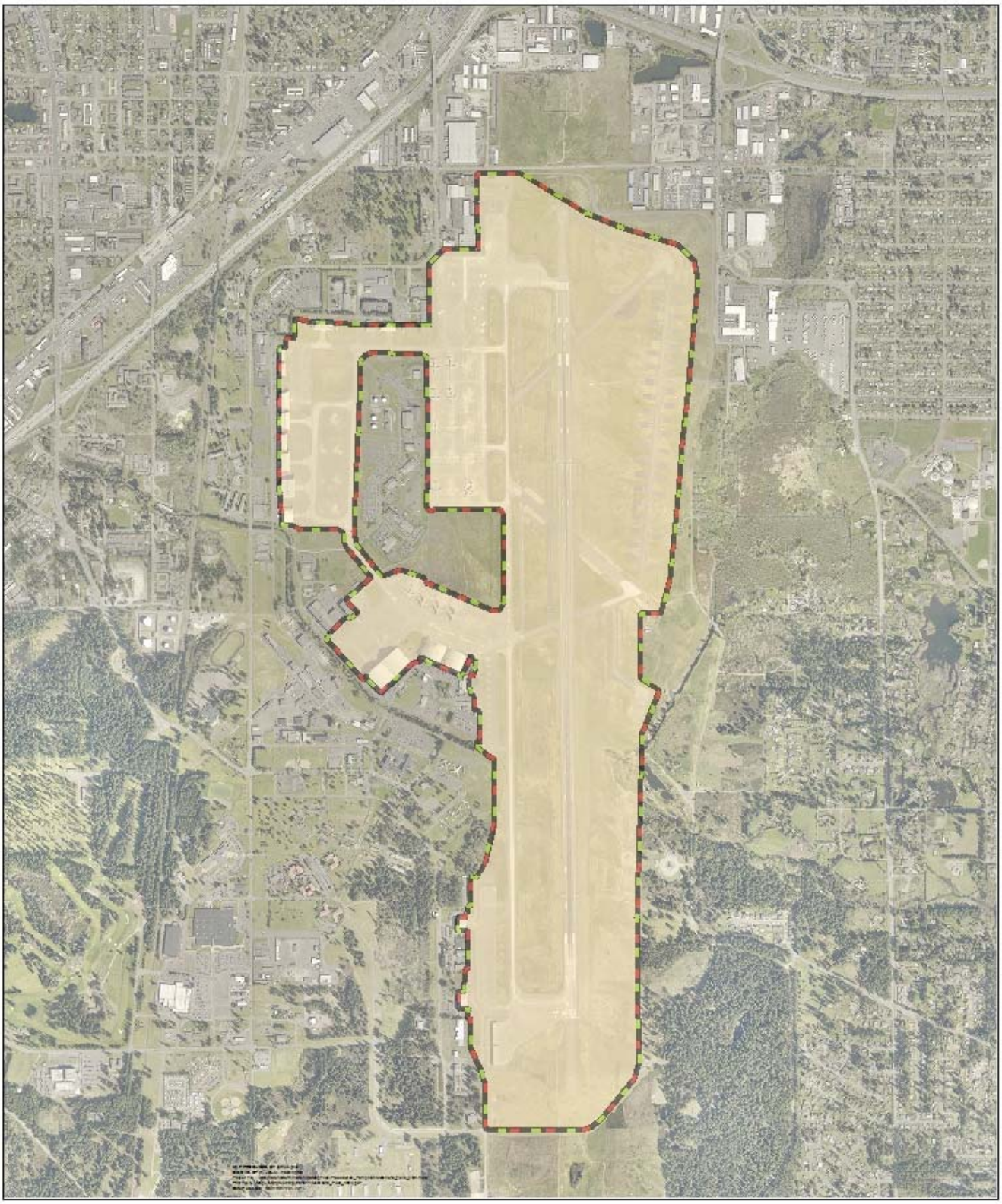
a. Stormwater Drainage Plans shall be submitted to the Stormwater Program. A minimum of 14 days shall be allotted for review for each submittal or re-submittal.

b. Designers of projects for new development or redevelopment are encouraged to coordinate with the Stormwater Program staff as early in the project as feasible. JBLM's current stormwater management practice of on-site treatment and infiltration makes it imperative that stormwater drainage plans are developed at an early stage of design.

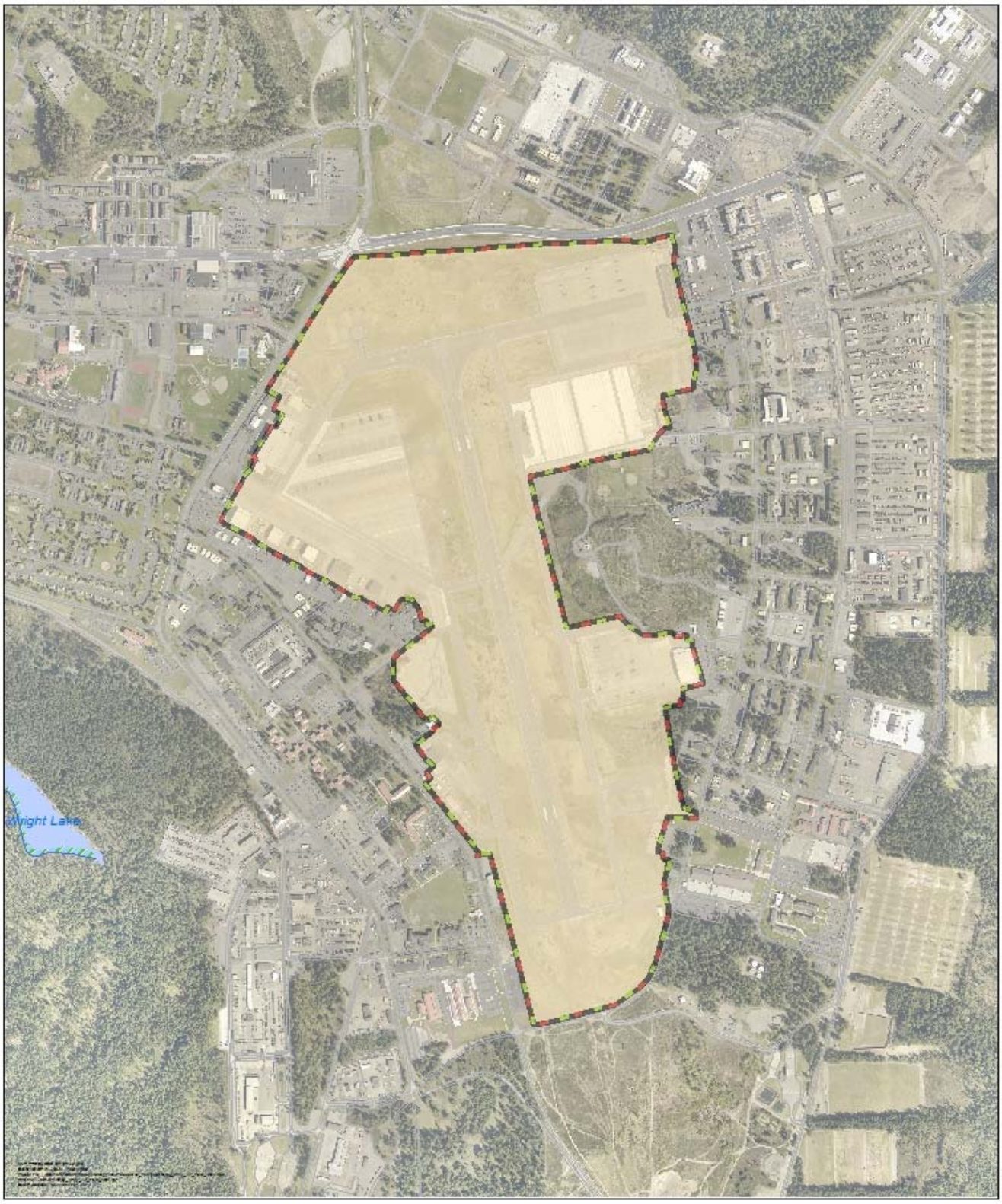
This page intentionally left blank

FIGURES

This page intentionally left blank



Air Operations Area	N 0 0.225 0.45 0.9 Miles 1 inch = 0.33 miles MAP DATA: ELLIPSOID: GRS 80 COORDINATE SYSTEM: UTM, Zone 10 HORIZONTAL DATUM: WGS 84	McCHORD FIELD AIR OPERATIONS AREA	Figure 1



Air Operations Area

N

0 0.125 0.25 0.5

Miles

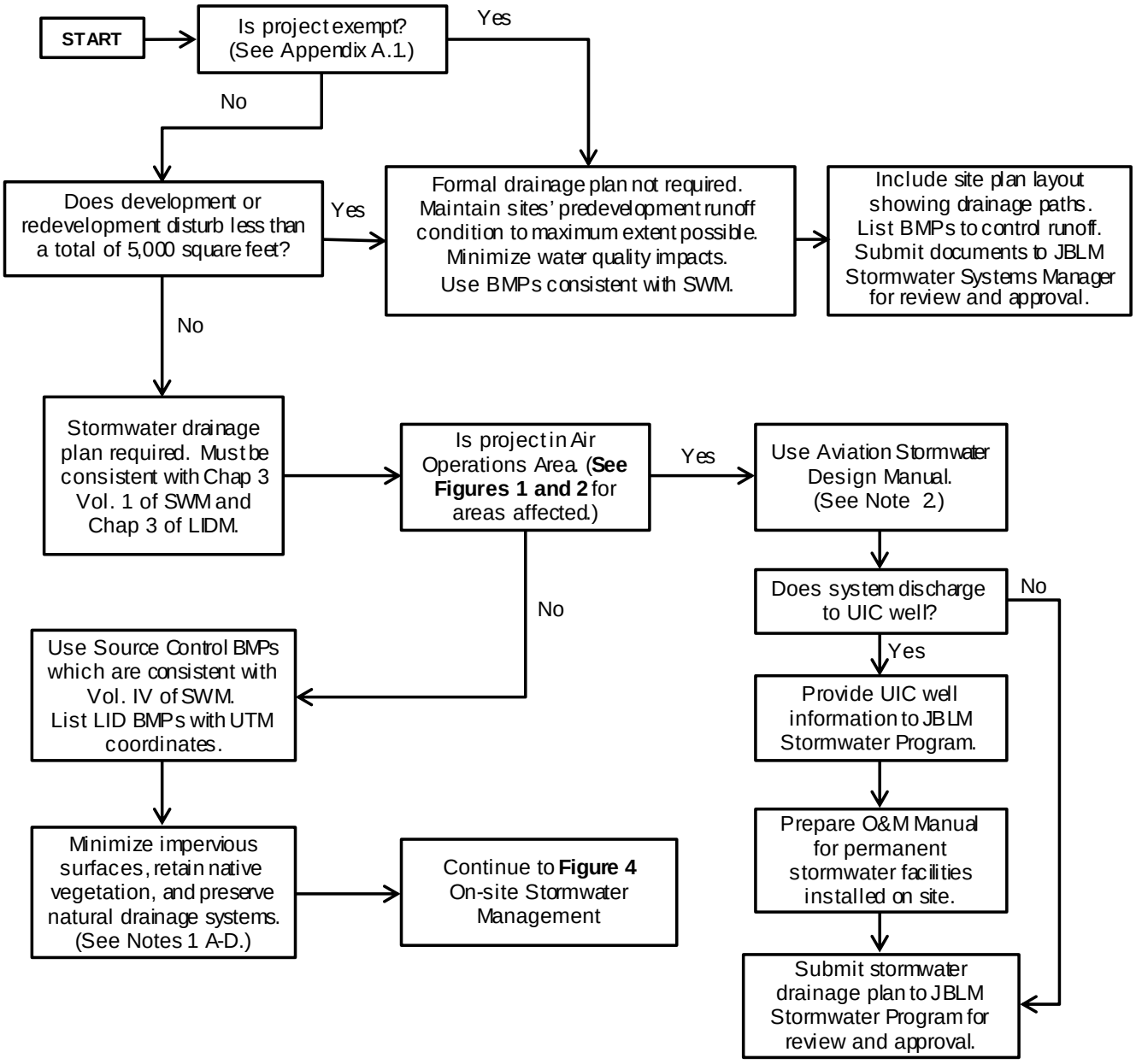
1 inch = 0.25 miles

MAP DATA:
ELLIPSOID: GRS 80
COORDINATE SYSTEM: UTM, Zone 10
HORIZONTAL DATUM: WGS 84

GRAY ARMY AIR FIELD
AIR OPERATIONS AREA

Figure
2

Figure 3 Source Control Requirements



NOTE 1.

A. Site design must minimize the project's roadway surfaces and parking areas, incorporates clustered development, and ensures that vegetated areas are designed to receive stormwater dispersion from all developed project areas;

B. Natural drainage patterns of the project site shall be maintained, and discharge from the new development or redevelopment project site shall occur at the natural location;

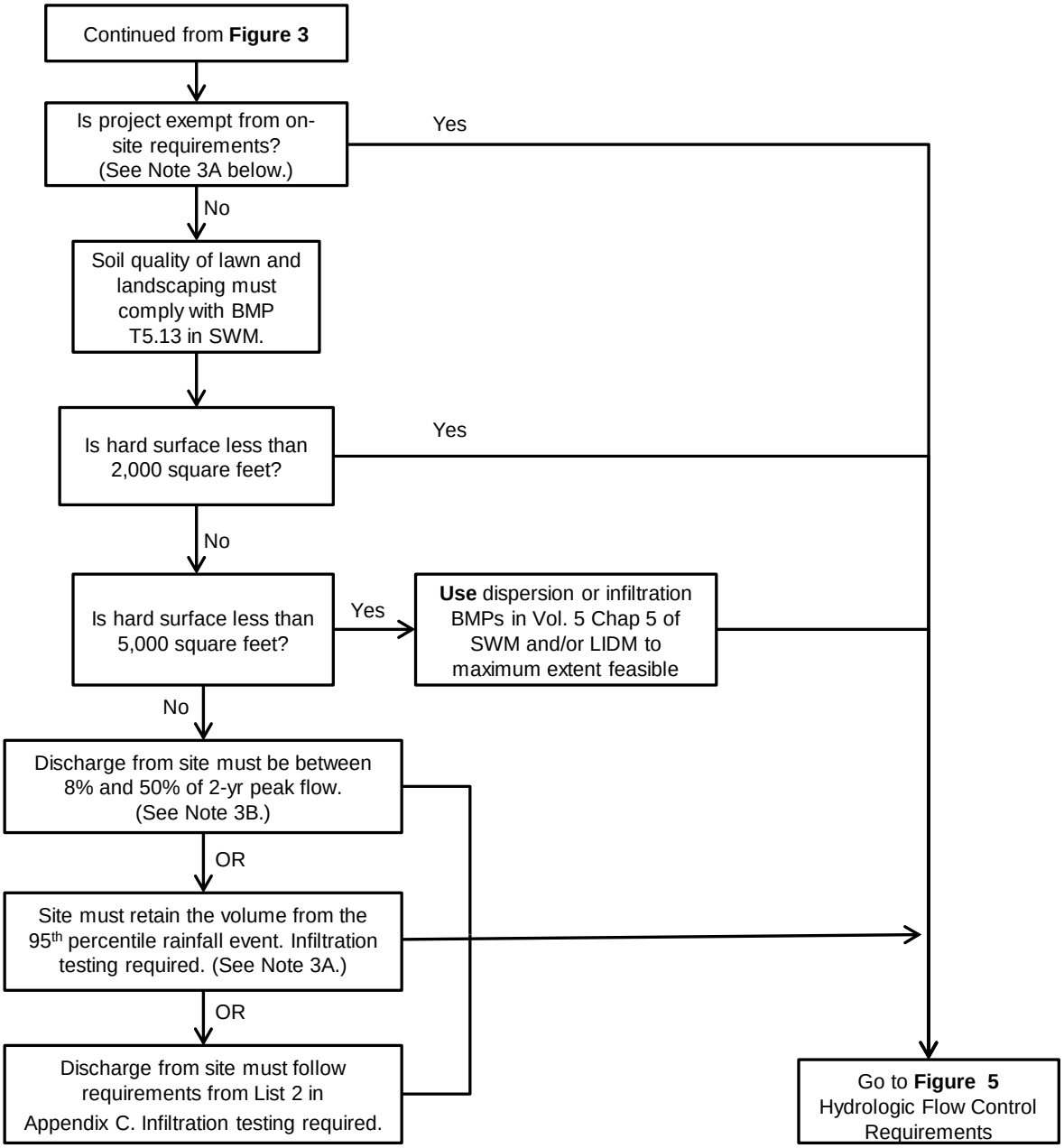
C. The manner by which runoff is discharged from the new development project site shall not cause a significant adverse impact to downstream receiving waters and/or down gradient properties; and

D. All outfalls shall use dissipation devices.

NOTE 2.

The Aviation Manual contains all components of the stormwater drainage plan except the Construction SWPPP. See the Construction Site Stormwater Runoff Control Plan.

Figure 4 On-Site Stormwater Management

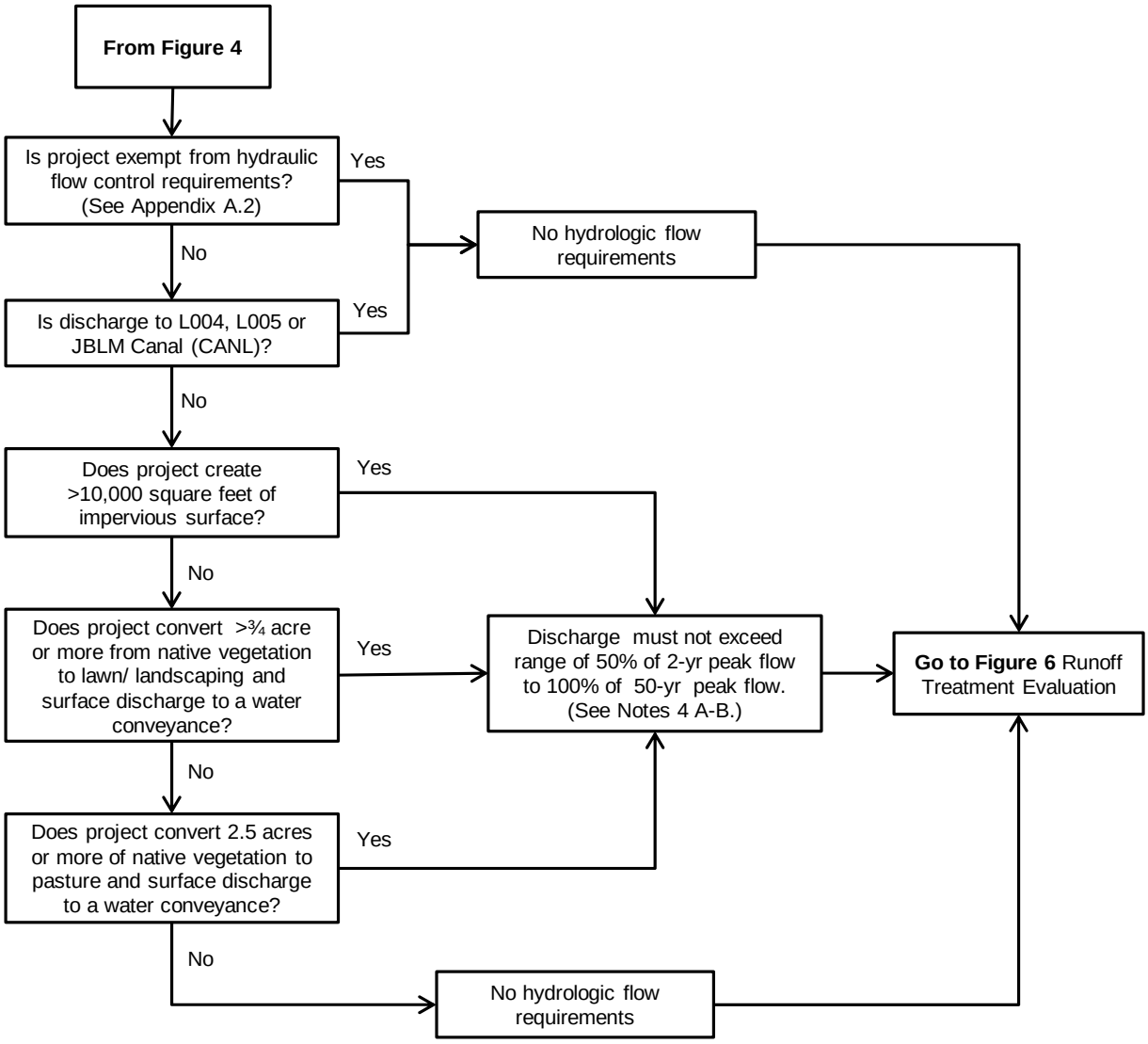


NOTE 3.

A. JBLM may exempt a project site from retaining the total runoff from the 95% rainfall event, provided compliance is documented. Feasibility must be determined by evaluating design criteria, limitations and infeasibility for each BMP in the SWM using List #2 and the competing needs described in Appendix C . The following information must be provided: Name, location and project description; reasons and documentation why full retention is not possible; and the estimated annual runoff volume that can and cannot be managed onsite.

B. The pre-development conditions for all new development or redevelopment projects must be "forested land cover" with applicable soil and soil grade, unless reasonable historic information indicates the site was prairie prior to settlement and may be modeled as "pasture" when using the Western Washington Hydrology Model (WWHM).

Figure 5 Hydraulic Flow Control Requirements

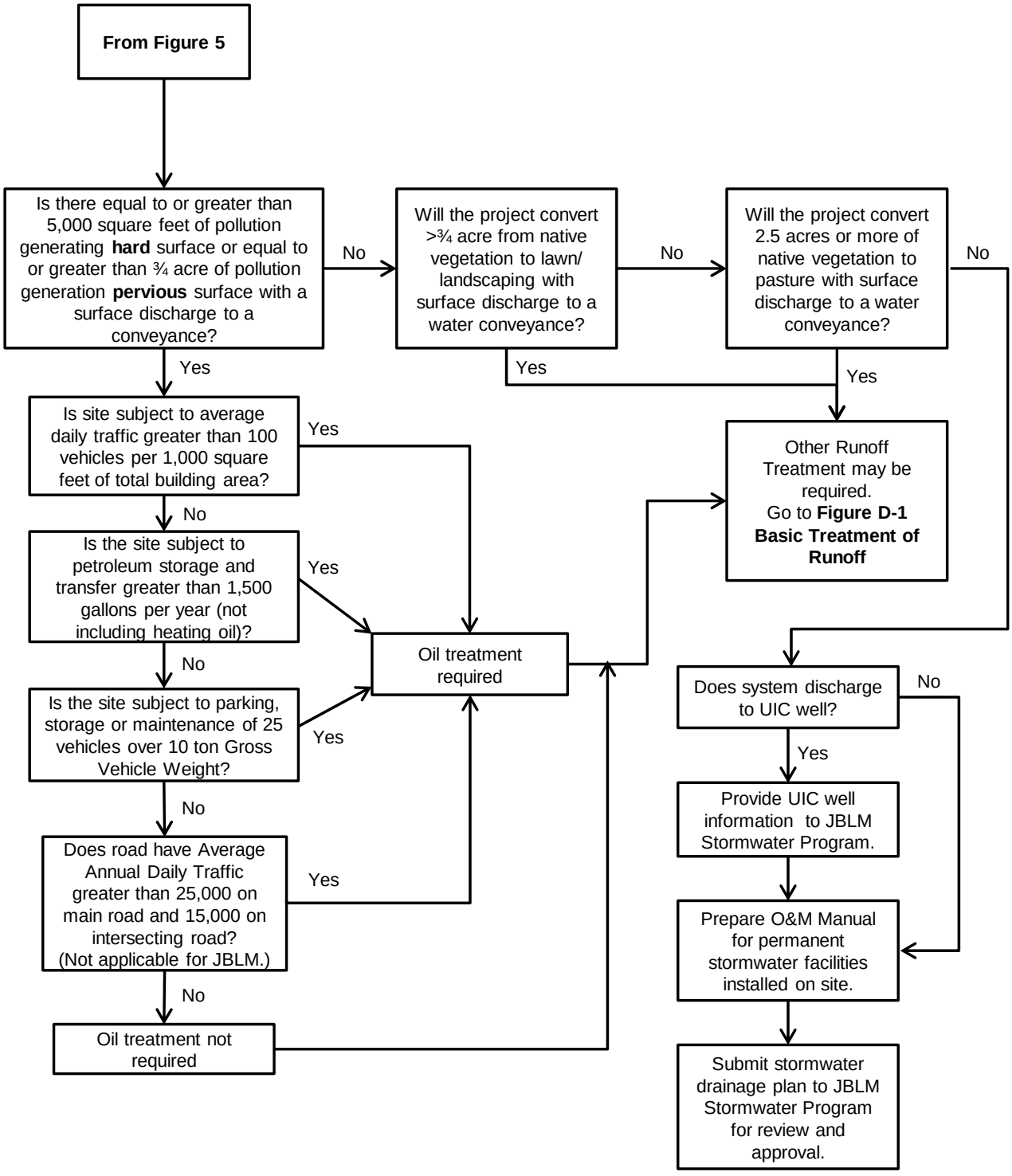


NOTE 4.

A. For the WWHM, pre-development condition for all new development and redevelopment project sites must be "forested land cover" (with applicable soil and soil grade), unless reasonable historic information indicates the site was prairie prior to settlement. May be then modeled as "pasture".

B. The designer must prioritize the use of small scale dispersion or infiltration practices, or other appropriate LID practices to meet this flow control requirement. The designer may not design new development or redevelopment sites to meet this hydrologic performance requirement for flow control solely through the use of large scale retention or detention practices.

Figure 6 Runoff Treatment Evaluation



TABLES

This page intentionally left blank

Table 1. UIC design requirements for infiltration trenches with soils considered a treatment Best Management Practice (BMP), (Ecology, 2008)

Infiltration trenches are designed to the SWM. UIC wells other than infiltration trenches with perforated pipe are required to be designed to the *Guidance for UIC Wells that Manage Stormwater*.	
Requirements	
Vadose zone separation between ground water/ impermeable layer and trench base	≥ 5 feet. See SWM Vol. III p. 3-84 Separation down to 3 feet may be allowed if mounding analysis determines no over topping into trench and overflow structure is adequate.
Depth of soil considered as treatment BMP	≥ 18 inches. See SWM Vol. III, p 3-84 (can be part of the 5 f5. Of required vadose zone separation)
Soil type	5 milliequivalents Cation Exchange Capacity per100 grams soils; Organic content unspecified, see SWM Vol. III, p. 3-84.
Required treatment	Pretreatment or any basic treatment BMP. See flow chart in Figure 6. - **Oil removal** at high use sites, doesn't include high AADT road, see SWM Vol. I, p. 4-5. - If trench receives just NPGIS*/roof runoff then only need catch basin for pretreatment.
Short term infiltration rate for treatment	SWM Vol III, p. 3-75. Use one of the 3 approaches, correction factor of 4 (appr.1) to 5.5 -18 (appr.3, p. 3-80, see SWM Vol III, p. 3-75.
In groundwater protection area? (well head or critical aquifer recharge area)	Check with JBLM Stormwater Program for information on well head protection areas.
Operation and Maintenance	Volume IV SWM
*NPGIS – non pollutant generating imperious surface. See definition in SWM	

Table 2. UIC design requirements for infiltration trenches used for flow control only. (Ecology, 2008)

Requirements	
Separation between ground water/ impermeable layer and trench base	5 feet
Soil type	None required
Treatment required, must use BMPs in Vol. III or IV of SWM	Solids removal; except of NPGIS*. Oil control for high use sites, SWM Vol. V p 2-3.
Short-term infiltration rate	No minimum
Long-term infiltration rate	No minimum
In groundwater protection area? (well head or critical aquifer recharge area)	Check with JBLM Stormwater Program for information on well head protection areas.
Operation and Maintenance	Volume IV SWM
*NPGIS – non pollutant generating imperious surface. See definition in SWM	

APPENDIX A
Exemptions from Stormwater Requirements

This page intentionally left blank

Appendix A

A.1 Exemptions from Stormwater Requirements. The practices described in this section are exempt from some or all stormwater requirements, even if such practices meet the definition of new development or redevelopment.

a. **Forest Practices.** Forest practices regulated under Title 222 WAC, except for Class IV General Forest Practices that are conversions from timber land to other uses are exempt from the requirements for new development or redevelopment.

b. **Commercial Agriculture:** Commercial agriculture practices involving working the land for production are generally exempt. However, the conversion from timberland to agriculture, and the construction of impervious surfaces are not exempt. Commercial Agriculture means those activities conducted on lands defined in Revised Code of Washington (RCW) 84.34.020(2) and activities involved in the production of crops or livestock for commercial trade. An activity ceases to be considered commercial agriculture when the area on which it is conducted is proposed for conversion to a nonagricultural use or has lain idle for more than five years, unless the idle land is registered in a federal or state soils conservation program, or unless the activity is maintenance of irrigation ditches, laterals, canals, or drainage ditches related to an existing and ongoing agricultural activity.

c. **Oil and Gas Field Activities or Operations.** Construction of drilling sites, waste management pits, and access roads, as well as construction of transportation and treatment infrastructure such as pipelines natural gas treatment plants, natural gas pipeline compressor stations, and crude oil pumping stations are exempt.

d. **Pavement Maintenance.**

(1) The following pavement maintenance practices are exempt:

(a) pothole and square cut patching,

(b) overlaying existing asphalt or concrete pavement with asphalt or concrete without expanding the area of coverage,

(c) shoulder grading, reshaping/regrading drainage systems,

(d) crack sealing,

(e) resurfacing with in-kind material without expanding the road prism,

(f) pavement preservation activities that do not expand the road prism, and

(g) vegetation maintenance.

(2) The following pavement maintenance practices are not exempt. They are considered redevelopment. The extent to which the SWM applies is explained for each circumstance.

(a) *Removing and replacing a paved surface to base course or lower, or repairing the pavement base*: If impervious surfaces are not expanded, Minimum Requirements #1 - #5 of the SWM apply. Extending the pavement edge without increasing the size of the road prism, or paving graveled shoulders: These are considered new impervious surfaces and are subject to the

minimum requirements that are triggered when the thresholds identified for new or redevelopment projects are met.

(b) *Extending the pavement edge without increasing the size of the road prism, or paving graveled shoulders*: These are considered new impervious surfaces and are subject to the requirements for new development or redevelopment.

(c) *Resurfacing by upgrading from dirt to gravel, asphalt, or concrete; upgrading from gravel to asphalt, or concrete; or upgrading from a bituminous surface treatment ("chip seal") to asphalt or concrete*: These are considered new impervious surfaces and are subject to the minimum requirements that are triggered when the thresholds identified for new or redevelopment projects are met.

e. **Underground Utility Projects.** Underground utility projects that replace the ground surface with in-kind material or materials with similar runoff characteristics only require a Construction Site Stormwater Pollution Prevention Plan. Follow guidance in Construction Stormwater Management Plan (Joint Base Lewis-McChord, 2017).

A.2 Exemptions from the Hydrologic Performance Requirement for Flow Control.

a. JBLM may exempt a new development or redevelopment project from managing the total runoff flow volume calculated to meet the hydrologic performance standard in Section 3-g (Flow Control), provided the Proponent fully documents that compliance with the hydrologic performance requirement for flow control cannot be attained due to severe economic project costs.

b. The Proponent must manage as much of the calculated flow volume as possible, and must provide the Stormwater Program with written records of all such project proposals. All exemptions from the hydraulic flow requirements shall be reviewed and approved by the Director of Public Works or authorized individual.

c. The Proponent must provide a written summary of the following information describing the requested exemption:

(1) Name, location, and a detailed description of the underlying facts supporting the Proponent's position including stormwater control strategies that will be deployed to manage as much of the calculated flow volume as possible.

(2) The marginal cost of full attainment along with a justification on why full attainment of the flow control requirement at the site would result in severe economic cost.

APPENDIX B
Drainage Plan Checklist

This page intentionally left blank

Stormwater Drainage Plan Checklist

Joint Base Lewis-McChord MS4 Permit

May 2017

Note:. This checklist will guide the designer/project manager in developing the Stormwater Drainage Plan as required by NPDES Permit WAS-026638 issued to Joint Base Lewis-McChord. This checklist is to be used in concert with the 2012 edition of the Stormwater Management Manual for Western Washington (SWMMWW) and is to be completed by those projects that have ground disturbance.

Project Name _____ **Date** _____

IJO No. _____ **USACE Project No.** _____

Package No._____ **JBLM Planning No.**_____

Project Designer _____ **Phone** _____

Organization_____ **E-mail**_____

JBLM PM _____ **Phone** _____

Organization _____ **E-mail** _____

Under the provisions of NPDES Permit WAS-026638, this project is (check appropriate box):

☐ Less than 5,000 ft^2, Complete Section II

☐ Project is exempt. Refer to Appendix A in Stormwater Development/Redevelopment Pamphlet. Attach documentation, complete Section II, and sign below.

☐ More than 5,000 ft^2 and subject to MS4 requirements (Complete Section III, submit Drainage Plan, and sign below)

☐ Project is in Airport Operations Area (see Figures 1 & 2) (Use supplemental checklist attached to this document and sign below).

_____ _____ _____

Project Designer Date Organization

Submit completed form to JBLM Stormwater Program (Bldg 2012)

SECTION II

1. Include a site plan layout.
2. Show area of disturbance and drainage paths for runoff.
3. Submit layout and this form to JBLM Water Systems Program Manager (Bldg 2012)

Drainage Plan

Bold items shall be included in Drainage Plan submittal

Prepare a documented Drainage Plan consistent with Chap 3 Vol 1 of Stormwater Management Manual for Western Washington (SWMMWW) and Chap 3 of the Low Impact Development Manual (LIDM). NOTE:

a) Describe project, include

____Vicinity map (i.e. where on JBLM)
____Site map
____Limits of development
____Existing area stormwater drainage features
____Outlines of drainage contributing runoff to site
____Future flow paths
____Other hydrologic features i.e. streams, ponds, wetlands, ditches
____Contours (2 ft up to 10% slope, 5 ft at 10-20%, 10ft at >20%)
____Flood hazard areas (if applicable)
____Well head protection areas (if applicable)

b) Geotechnical soils report by qualified professional which includes

____Logs for test pits or borings at locations for installed BMPs
____Soil type (grain size, texture, cation exchange capacity, stratification)
____The results of infiltration tests at locations where infiltration will be utilized

c) A preliminary layout which:

____Minimizes land disturbance
____Preserves natural vegetation
____Locates impervious areas over less permeable soils
____Clusters buildings
____Utilizes natural drainage areas

d) ____Highlight decision process on **Figures 3 through 6** and include in Drainage Plan.

Source Control Requirements

(see Figure 3 of Development/Redevelopment Pamphlet)

_____**List in a table source control Best Management Practices (BMPs)** used in Drainage Plan consistent with Vol. IV of SWMMWW. Include:

1. **BMP type (e.g. infiltration trench, bioswale, etc.)**
2. **Location in UTM84 coordinates (meters)**
3. **Drainage area served by BMP (sq ft)**
4. **Estimated cost including installation**

_____**List efforts to minimize impervious surfaces, retain native vegetation, and preserve natural drainage systems per the SWMMWW**. Site design must:

a) ____Minimize the project's roadway surfaces and parking areas, incorporate clustered development, and ensure that vegetated areas are designed to receive stormwater dispersion from all developed project areas;

b) ____Maintain natural drainage patterns of the project, and discharge from the new development or redevelopment project site shall occur at the natural location;

c) ____Prevent runoff from causing a significant adverse impact to downstream receiving waters and/or down gradient properties; and

d) ____Use dissipation devices at outfalls

On-site Stormwater Management

(see Figure 4 of Development/Redevelopment Pamphlet)

_____If Project is exempt from On-Site requirements (Figure 4, Note 3B**) attach documentation to Drainage Plan.**

_____**Document that soil quality of lawn and landscaping complies with BMP T5.13** in SWMMWW

_____Conduct pre and post development runoff calculations using Ecology Western Washington Hydrology Model or other approved method. **Include calculations or summary printout in Drainage Plan**

_____Evaluate alternatives for discharge in Drainage Plan.

Hydraulic Flow Control Requirements

(see Figure 5 of Development/Redevelopment Pamphlet)

_____If Project is exempt from Hydraulic Flow Control (Appendix A2) **attach documentation** in Drainage Plan.

_____Determine discharge requirements (See Figure 5). Indicate calculation method. **Include a summary of calculations or the summary pages from the computer model used**.

_____Calculate discharge which must not exceed the pre development range of 50% of 2-yr peak flow to 100% of the 50-year peak flow. **Include calculations**.

_____Prioritize the use of small scale dispersion or infiltration practices, or other appropriate Low Impact Development practices to meet this flow control requirement. The designer may not design new development or redevelopment sites to meet this hydrologic performance requirement for flow control solely through the use of large scale retention or detention practices. List dispersion or infiltration BMPs in Drainage Plan.

Runoff Treatment

(see Figure 6 of Development/Redevelopment Pamphlet)

_____If Oil Treatment is required, **list BMPs utilized.** If Runoff Treatment is not required, Go to Underground Injection Control Section

_____If other Runoff Treatment is required (i.e. basic sediment treatment), **list BMPs utilized.**

_____If other Runoff Treatment is required (i.e. enhanced/metals removal treatment), **list BMPs utilized.**

Underground Injection Control (UIC)

_____If system discharges to a UIC (See Tables 1 and 2, and Appendix C of Development/Redevelopment Pamphlet), **provide system information to JBLM Stormwater Program Manager** for registration with Ecology.

Operations and Maintenance Manual

_____Prepare Operation and Maintenance Manual for permanent BMP's to be constructed in this project. **Include with the Drainage Plan**.

Submittals

_____ **Submit Drainage Plan Report** to Stormwater Program. (Allow 2 weeks for review of each submittal or re-submittal).

Summary of Drainage Plan Contents

1. Paragraph describing the project include location, disturbed area.
2. Vicinity Map
3. Site Maps showing
    a. Layout with bldg., landscaping, roads/pavement, 2 ft contours
    b. Drainage areas
    c. BMP locations & other stormwater features (culverts, catchbasins)
    d. Other hydrologic features (streams, ponds, etc)
4. Stormwater geotechnical information
5. Table listing drainage areas, runoff volume
6. Table listing permanent BMPs, location in UTM coordinates, area and volume served by each BMP, estimated cost
7. Figures with decision path highlighted
8. Calculations and/or Summary printout of Hydrologic Model results including runoff graph
9. O&M Manual

APPENDIX C
Alternative Discharge Requirements for On-Site Stormwater Management

This page intentionally left blank

APPENDIX C. LIST 2. Alternative Discharge Requirements for On-Site Stormwater Management

C-1. Discharge Requirements. Discharge from a site may be evaluated per the requirements of List #2, in Volume I, Section 2.5.5 of the SWM which is documented below. For each runoff surface, evaluate the BMPs in the order listed for that type of surface. Use the first BMP that is considered feasible. No other On-site Stormwater Management BMP is necessary for that surface. The objective is to use practices distributed across a development that reduce the amount of disruption of the natural hydrologic characteristics of the site.

a. Feasibility shall be determined by evaluation against:

(1) Design criteria, limitations, and infeasibility criteria identified for each BMP in the SWM; and

(2) Competing needs criteria including requirements of the following federal or state laws, rules, and standards:

(a) Historic Preservation Laws and Archaeology Laws as listed at: http://www.dahp.wa.gov/learn-and-research/preservation-laws,

(b) Federal Superfund or Washington State Model Toxics Control Act

(c) Federal Aviation Administration requirements for airports,

(d) Americans with Disabilities Act.

(e) Where a LID requirement has been found to be in conflict with special design criteria adopted and being implemented pursuant to the JBLM Master Plan, the existing Plan may supersede or reduce the LID requirement.

(f) Public health and safety standards.

(g) Transportation regulations to maintain the option for future expansion or multi-modal use of public rights-of-way.

(h) A JBLM Critical Area that provides protection of tree species.

b. Lawn and landscaped areas. Post-Construction Soil Quality and Depth in accordance with **BMP T5.13** in Chapter 5 of Volume V of the SWM.

c. Roofs.

(1) Full Dispersion in accordance with **BMP T5.30** in Chapter 5 of Volume V, or Downspout Full Infiltration Systems in accordance with **BMP T5.10A** in Section 3.1.1 in Chapter 3 of Volume III.

(2) Bioretention (See Chapter 7 of Volume V) facilities that have a minimum horizontally projected surface area below the overflow which is at least 5% of the total surface area draining to it.

(3) Downspout Dispersion Systems in accordance with **BMP T5.10B** in Section 3.1.2 in Chapter 3 of Volume III.

(4) Perforated Stub-out Connections in accordance with **BMP T5.10C** in Section 3.1.3 in Chapter 3 of Volume III.

d. Other Hard Surfaces.

(1) Full Dispersion in accordance with **BMP T5.30** in Chapter 5 of Volume V of the SWM.

(2) Permeable pavement1 in accordance with **BMP T5.15** in chapter 5 of Volume V of the SWM.

(3) Bioretention BMP's (See Chapter 7, Volume V of the SWM) that have a minimum horizontally projected surface area below the overflow which is at least 5% of the total surface area draining to it.

(4) Sheet Flow Dispersion in accordance with **BMP T5.12**, or Concentrated Flow Dispersion in accordance with **BMP T5.11** in Chapter 5 of Volume V of the SWM.

APPENDIX D
Runoff Treatment Requirements for New Development and Redevelopment Project Sites

This page intentionally left blank

APPENDIX D

Runoff Treatment Requirements for New Development and Redevelopment

D-1. Runoff Treatment Requirements. Runoff treatment requirements are described in the following sections. Figures D-1 and D-2 shows the runoff treatment evaluation process.

a. Treatment-Type Thresholds.

(1) Oil Control Figure 6: Treatment to achieve Oil Control applies to projects that have "high-use sites." High-use sites are those that typically generate high concentrations of oil due to high traffic turnover or the frequent transfer of oil. High-use sites include:

(a) An area of a commercial or industrial site subject to an expected average daily traffic (ADT) count equal to or greater than 100 vehicles per 1,000 square feet of gross building area;

(b) An area of a commercial or industrial site subject to petroleum storage and transfer in excess of 1,500 gallons per year, not including routinely delivered heating oil;

(c) An area of a commercial or industrial site subject to parking, storage or maintenance of 25 or more vehicles that are over 10 tons gross weight (trucks, buses, trains, heavy equipment, etc.);

(d) A road intersection with a measured ADT count of 25,000 vehicles or more on the main roadway and 15,000 vehicles or more on any intersecting roadway, excluding projects proposing primarily pedestrian or bicycle use improvements.

(2) Phosphorus Treatment Figure D-1. The requirement to provide phosphorous control is determined by the Department of Ecology (for example, through a waste load allocation as part of an EPA approved Total Maximum Daily Load [TMDL] analysis). There is currently no EPA approved TMDL for American Lake, although it is a water body reported under section 305(b) of the Clean Water Act, and is designated by the State of Washington as not supporting beneficial uses due to phosphorous. The Permittee should consider phosphorus treatment for any discharges from new development or redevelopment projects that will discharge to American Lake.

(3) Basic Treatment Figure D-1. Basic Treatment is required for each of the following circumstances:

(a) Project sites that discharge to the ground, UNLESS:

(i) The soil suitability criteria for infiltration treatment are met; (see Chapter 3 of Volume III- of the SWM) and alternative pretreatment is provided (see Chapter 6, Volume V of the SWM); or

(ii) The project site uses infiltration strictly for flow control – not treatment, and the discharge is within one quarter mile of a phosphorus sensitive lake (use a Phosphorus Treatment facility); or

(iii) The project site is industrial, commercial, multi-family residential, or a high AADT road (consistent with the Enhanced Treatment-type thresholds listed above) and is within ¼ mile of a fresh water designated for aquatic life use or that has an existing aquatic life use (use an Enhanced Treatment facility).

(b) Residential projects not otherwise needing phosphorus control as designated by USEPA, the Department of Ecology, or by JBLM;

(c) Project sites discharging directly (or indirectly through a MS4) to Basic Treatment Receiving Waters (Appendix I-C of the 2012 SWM);

(d) Project sites that drain to freshwater that is not designated for aquatic life use, and does not have an existing aquatic life use; and project sites that drain to waters not tributary to waters designated for aquatic use or that have an existing aquatic life use;

(e) Landscaped areas of industrial, commercial, and multi-family project sites, and parking lots of industrial and commercial project sites that do not involve pollution-generating sources (e.g., industrial activities, customer parking, storage of erodible or leachable material, wastes or chemicals) other than parking of employees' private vehicles. For developments with a mix of land use types, the Basic Treatment requirement shall apply when the runoff from the areas subject to the Basic Treatment requirement comprise 50% or more of the total runoff.

(4) Enhanced Treatment Figure C-2: Except where specified under Section I.3, Basic Treatment, enhanced treatment for reduction in dissolved metals is required for the following project sites that:

(a) Discharge directly to freshwaters or conveyance systems tributary to freshwaters designated for aquatic life use or that have an existing aquatic life use; or

(b) Use infiltration strictly for flow control – not treatment- and the discharge is within ¼ mile of a freshwater designated for aquatic life use or that has an existing aquatic life use:

(i) Industrial project sites,

(ii) Commercial project sites,

(iii) Multi-family project sites, and

(iv) High AADT roads. Roads with an AADT of 15,000 or greater unless discharging to a 4th Strahler order stream or larger. Roads with an AADT of 30,000 or greater if discharging to a 4th Strahler order stream or larger (as determined using 1:24,000 scale maps to delineate stream order). As of 2017, high AADT roads on JBLM that meet this criteria are:

- 41st Division Dr from the Main Gate to Pendleton,
- Jackson Ave from the Madigan Gate to Wilson Ave, and
- 41st Division Drive from the Lewis North Gate to A St.

(c) Any areas of the above-listed project sites that are identified as being subject to Basic Treatment requirements are not subject to the Enhanced Treatment requirements. For developments with a mix of land use types, the Enhanced Treatment requirement shall apply

when the runoff from the areas subject to Enhanced Treatment comprises 50% or more of the total runoff.

b. **Treatment Facility Sizing.** Size all stormwater treatment facilities for the entire area that drains to them, even if some of those areas are not pollution-generating. The volume of runoff predicted from a 24-hour storm with a 6-month return frequency (i.e.the 6-month, 24-hour storm) is considered the Water Quality Design Storm Volume. Wetpool facilities are sized based upon the volume of runoff predicted through use of the Natural Resource Conservation Service curve number equations in Chapter 2 of Volume III SWM, for the 6-month, 24-hour storm. Alternatively, when using an approved continuous runoff model, the water quality design storm volume shall be equal to the simulated daily volume that represents the upper limit of the range of daily volumes that accounts for 91% of the entire runoff volume over a multi-decade period of record.

c. **Water Quality Design Flow Rate.**

(1) Preceding Detention Facilities or when Detention Facilities are not required: The flow rate at or below which 91% of the runoff volume, (as estimated by an approved continuous runoff model) will be treated. Design criteria for treatment facilities are assigned to achieve the applicable performance goal (e.g., 80% TSS removal) at the water quality design flow rate. At a minimum, 91% of the total runoff volume, as estimated by an approved continuous runoff model, must pass through the treatment facility(ies) at or below the approved hydraulic loading rate for the facility(ies).

(2) Downstream of Detention Facilities: The water quality design flow rate must be the full 2-year release rate from the detention facility.

d. **Treatment Facility Selection, Design, and Maintenance.** Stormwater treatment facilities must be:

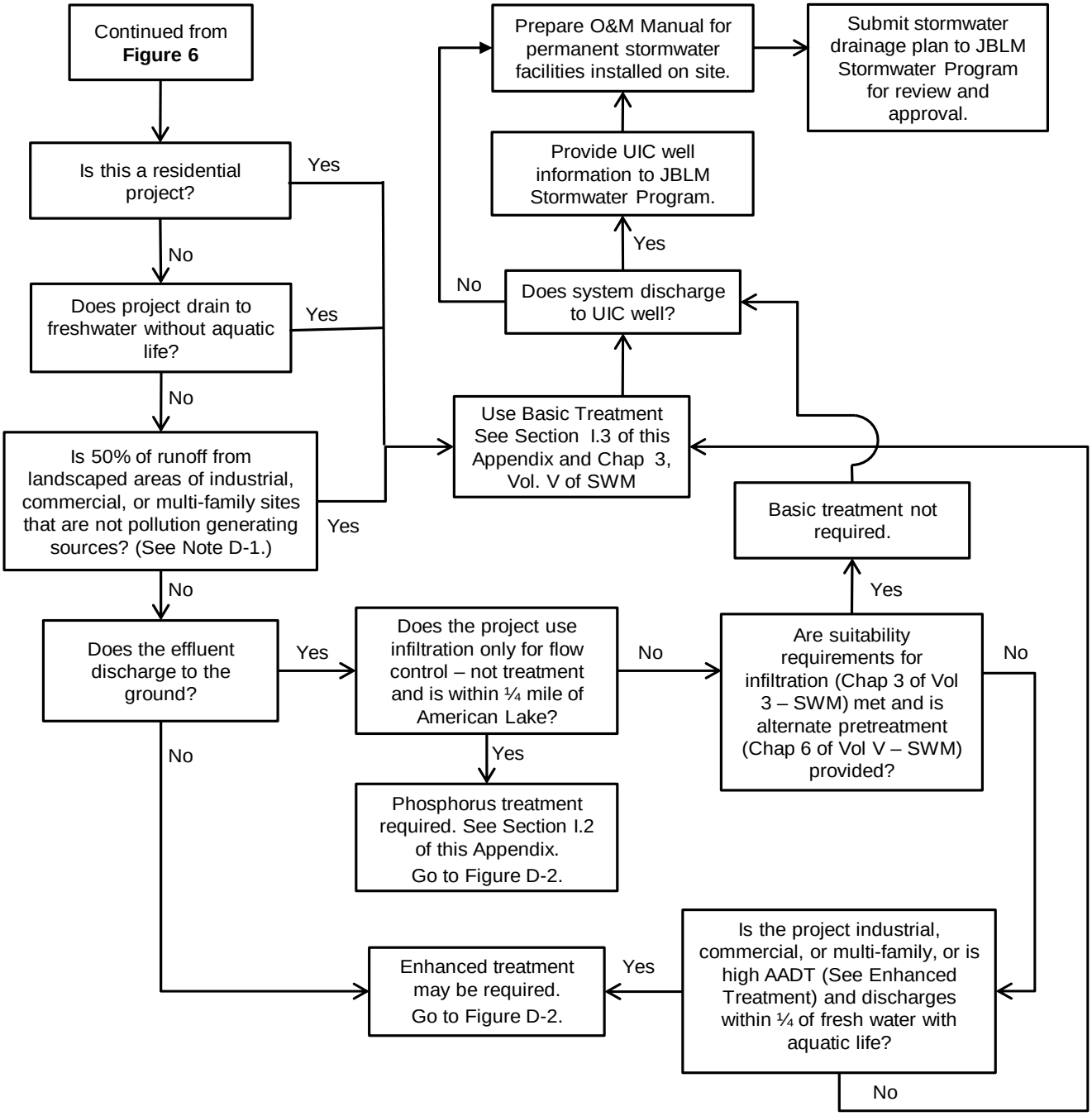
(1) Selected in accordance with the process identified in Vol. I Chap. 4, and Vol. V Chap. 2 of the SWM,

(2) Designed in accordance with the design criteria in Vol. V of the 2012 SWM, and

(3) Maintained in accordance with the maintenance schedule in Vol. V of the SWM.

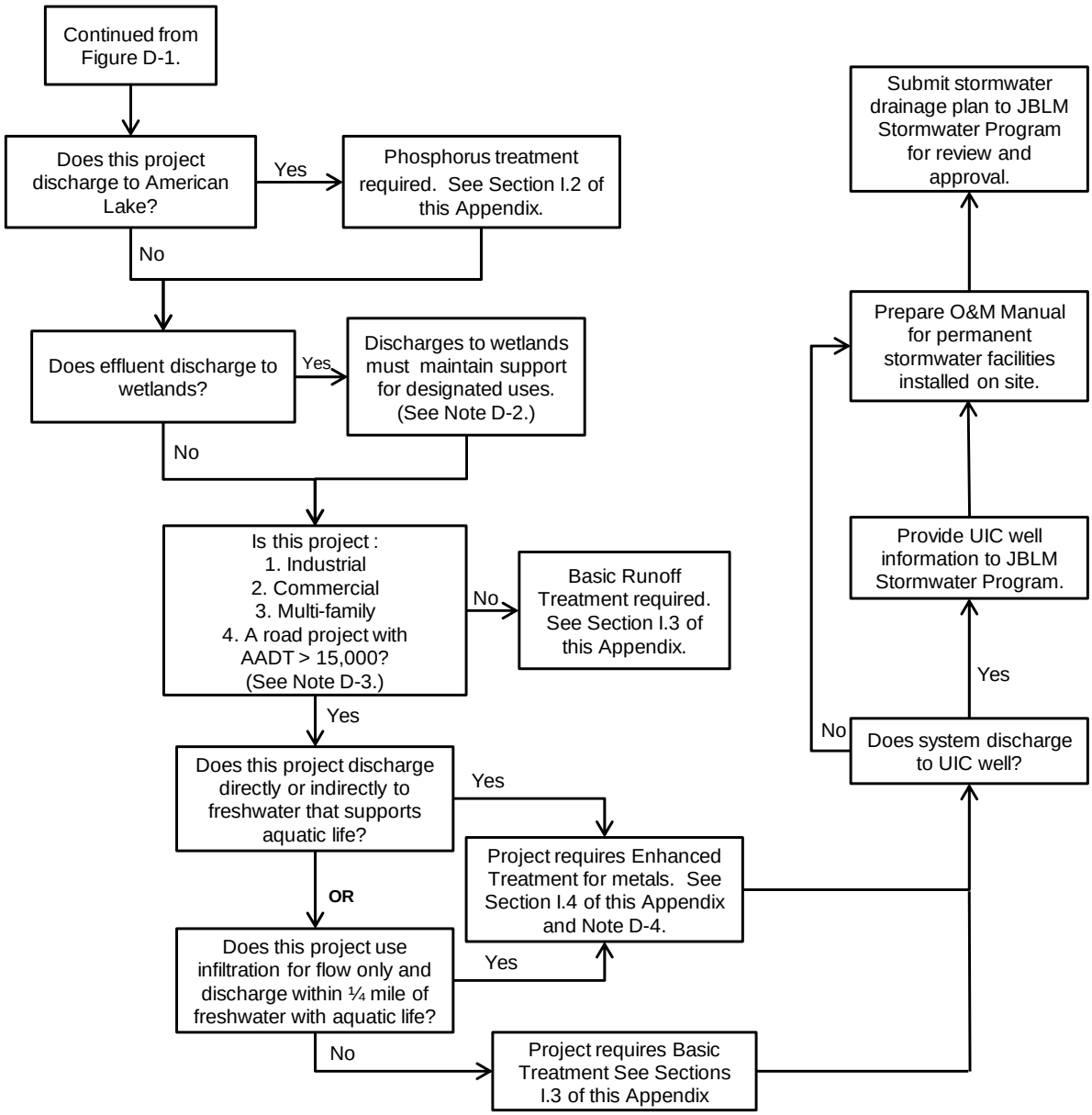
e. **Additional Requirements.** The discharge of untreated stormwater from pollution-generating hard surfaces to ground water will not be authorized by JBLM, except for the discharge achieved by infiltration or dispersion of runoff through use of On-site Stormwater Management BMPs in accordance with Vol. V Chap. 5, and Chapter 7, of the SWM; or by infiltration through soils meeting the soil suitability criteria in Vol. III Chap. 3 of Volume III of the SWM.

Figure D-1 Basic Treatment of Runoff



NOTE D-1. Pollution generating sources are industrial activities, customer parking areas, areas for storage of erodible or leachable material, wastes or chemicals. Employee parking areas are not included.

Figure D-2 Enhanced Treatment of Runoff



NOTE D-2 Wetlands must maintain the hydrologic conditions, hydrophytic vegetation, and substrate characteristics. The hydrologic analysis must use the existing land cover condition to determine the existing hydrologic conditions, unless directed otherwise by JBLM. See Appendix D of Vol 1 of the SWM for guidance.
NOTE D-3 As of 2014, the following roads have AADT's greater than 15,000: 41st Division between the Liberty Gate and Pendleton, Jackson Ave between the Madigan Gate and Wilson Ave; or 41st Division between the Lewis-North Gate and A St.
NOTE D-4 Enhanced treatment shall be used throughout mixed land use areas where 50% of runoff is from areas requiring enhanced treatment .

This page intentionally left blank

APPENDIX E
Guidance for UIC Wells that Manage Stormwater

This page intentionally left blank

Guidance for UIC Wells that Manage Stormwater

December 2006
Publication Number 05-10-067

Chapter 1 – Introduction and Background

This document provides technical guidance for stormwater wells regulated under the Underground Injection Control (UIC) program. For convenience, we will refer to these as UIC wells. UIC wells that are used for stormwater are also commonly referred to as drywells.

The purpose of this document is to provide design and pretreatment best management practices (BMPs) for UIC wells used along roads, parking areas and also roof runoff and built on or after February 3, 2006. These UIC wells are referred to as "new" UIC wells.

The UIC rule, Chapter 173-218 WAC, requires a well assessment for UIC wells that were constructed prior to February 3, 2006. These UIC wells are referred to as "existing" UIC wells. This document can also be used to complete the well assessment for existing wells.

Stormwater

Stormwater is the water from rainstorms or snow melt that runs over land into ponds, lakes, streams, marine waters, wetlands, drainage ditches, evaporation ponds, and drywells.

As stormwater flows, it contacts surfaces that contain pollutants. Roads and parking lots can contribute oils and metals. Roofs on industrial buildings can collect chemicals that are vented out of the building and wash off when it rains. Grassy areas like golf courses, cemeteries, and playing fields may contribute fertilizers and pesticides.

The purpose of managing stormwater is two fold: to prevent flooding and to prevent water pollution. Drainage systems are designed to collect and transport stormwater runoff to prevent flooding, and treatment systems are designed to control pollution. Managing stormwater at the site, such as by using a UIC well, can also contribute to the recharge of ground water resources.

For chemicals that are not easy to remove from stormwater, pollution control means going to the source and preventing it from contacting stormwater in the first place. The methods of preventing stormwater pollution are referred to as "best management practices."

UIC Program

The Underground Injection Control program was created by Congress to protect underground sources of drinking water from discharges of fluids to the ground. The UIC program in the state of Washington is administered by the Department of Ecology. In 1984, the Department of Ecology adopted Chapter 173-218 WAC - Underground Injection Control to implement the program.

In Washington all ground water is protected equally under RCW 90.48 and Chapter 173-200 WAC Water Quality Standards for Ground Waters of the State of Washington.

The two basic requirements of the UIC Program are:

- Register UIC wells with the Washington State Department of Ecology unless the wells are located on tribal land. (Those wells should be registered with the Environmental Protection Agency).
- Make sure that current and future underground sources of ground water are not endangered by pollutants in the discharge (non-endangerment standard).

Since stormwater picks up contaminants as it runs over the land surface, it can pollute ground water once infiltration occurs.

Pollution of ground water from stormwater discharges can be prevented by careful design of the UIC well, strategic siting and effective operation and maintenance. Pollution can also be prevented by use of treatment before discharge to the sub-surface and by reducing the stormwater contact with potential sources of contamination. These methods are covered in this technical guidance.

1.1 Development of this technical guidance

The UIC rule was revised in consultation with the UIC Rule Advisory Committee. The UIC rule was adopted and became effective on February 3, 2006. A subcommittee of the Stormwater Management Manual for Eastern Washington committee developed the draft version of this document with statewide stakeholder input and public review. This document was originally published as interim technical guidance in Ecology Publication Number 04-10-076, the *Stormwater Management Manual for Eastern Washington*.

This guidance replaces the section in the Department of Ecology *Stormwater Management Manual for Eastern Washington (SMMEW)*, Section 5.6 that refers to UIC wells; however, the rest of the manual applies.

When using this document, please refer also to the Ecology stormwater management manuals for eastern and western Washington or an equivalent department approved manual. An example of an equivalent manual is the Washington State Department of Transportation Highway Runoff Manual:
http://www.wsdot.wa.gov/fasc/EngineeringPublications/Manuals/HighwayRunoffManual.pdf

1.2 Definition of a UIC well

A UIC well is a manmade subsurface fluid distribution system designed to discharge fluids into the ground and consists of an assemblage of perforated pipes, drain tiles, or other similar mechanisms, or a dug hole that is deeper than the largest surface dimension (WAC 173-218-030).

Subsurface infiltration systems include drywells, pipe or French drains, drain fields, and other similar devices that are used to discharge stormwater directly into the ground.

Drywells are UIC wells completed above the water table so that the bottom and sides are typically dry except when receiving fluids. Drywells may be stand-alone or as part of a larger drainage system, such as the overflow for a bio-infiltration swale or other stormwater treatment BMP.

Infiltration trenches with perforated pipe are considered to be UIC wells. This type of infiltration trench must be registered with Ecology. However, they must be designed, constructed, operated, and maintained according to an Ecology stormwater manual or another equivalent department approved manual to be rule authorized. This guidance does not apply except for the registration requirement.

Typical UIC stormwater wells (drywells)

The following are not UIC wells; therefore, this guidance does not apply:

- Buried pipe and/or tile networks that serve to collect water and discharge that water to a conveyance system or to surface water.
- Surface infiltration basins and flow dispersion stormwater infiltration facilities.
- Infiltration trenches designed **without** perforated pipe or a similar mechanism.

APPENDIX F
References

This page intentionally left blank

APPENDIX F. REFERENCES

a. Clear Creek Solutions, 2014. Western Washington Hydrology Model – 2012 User Manual. Prepared by Clear Creek Solutions, Inc., Olympia, WA. May. www.clearcreeksolutions.info/ftp/public/downloads/WWHM2012/wwhm2012.msi,

b. Ecology, 2006. *Guidance for UIC Wells that Manage Stormwater.* Prepared by the Washington State Department of Ecology Water Quality Program. Publication Number 05-10-067. December.

c. Ecology, 2008. Summary of Design Requirements for Infiltration Trenches. Ecology Underground Injection Control Program website: http://www.ecy.wa.gov/programs/wq/grndwtr/uic/InfiltTrenchDesign-EastsideWestside4-2-5-2.pdf . September.

d. Hinman & Wulkan, 2012. Low Impact Development – Technical Guidance Manual for Puget Sound. Prepared by Washington State University Extension Faculty and Puget Sound Partnership. Publication No. PSP 2012-3. December.

e. Joint Base Lewis-McChord, 2017. Construction Stormwater Management Plan. Prepared by Public Works Environmental Division. Joint Base Lewis McChord. May.

f. U. S. Army , 2013. Army Low Impact Development Technical User Guide. Office of the Assistant Chief of Staff for Installation Management. Prepared by U.S. Army Corps of Engineers, Baltimore District. 4 January.

g. U. S. Environmental Protection Agency, 2014. Authorization to Discharge Under the National Pollutant Discharge Elimination System. Permit No. WAS-026638. Permit modification issued to Joint Base Lewis-McChord by EPA Region 10. December 4.

h. Washington State Department of Ecology, 2012. Stormwater Manual for Western Washington. Volumes I to V. Prepared by Washington Department of Ecology Water Quality Program. Olympia, WA. Publication No. 12-10-030. August.

i. Washington State Department of Transportation, 2008. Aviation Stormwater Design Manual. Prepared by Washington Department of Transportation, Environmental and Engineering Programs Design Office. Olympia, WA. Design Manual M 3041.00. December.