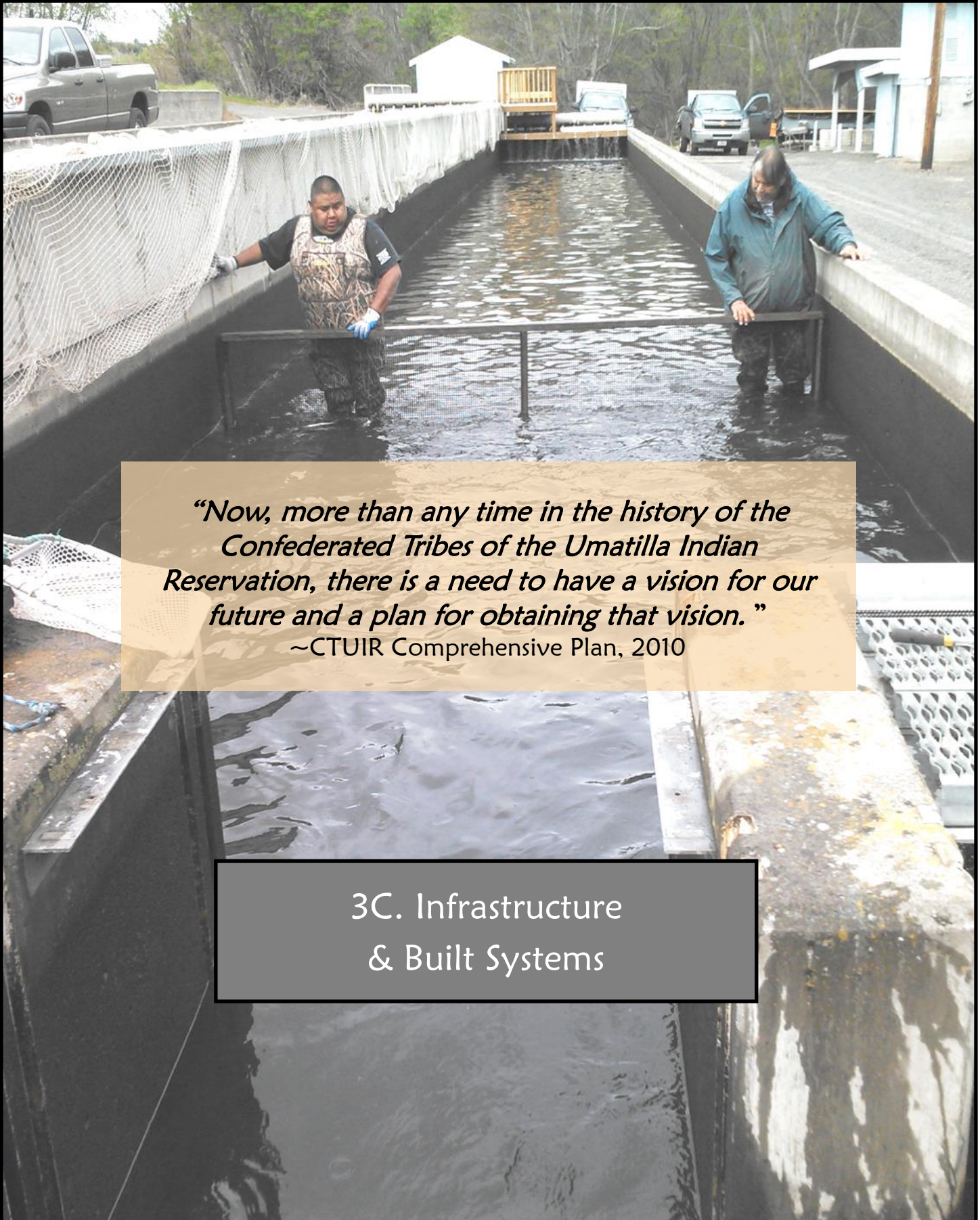


Chapter 3 : Šapátunxwit ~ Impacts and Adaptation Goals



“Now, more than any time in the history of the Confederated Tribes of the Umatilla Indian Reservation, there is a need to have a vision for our future and a plan for obtaining that vision.”

~CTUIR Comprehensive Plan, 2010

3C. Infrastructure & Built Systems

Climate Impacts for Physical Infrastructure

“As the area’s population increases, there will be an increase of automobile and truck traffic that will place additional stress on local roads, bridges and infrastructure.

The impact of an emergency can disrupt automobile traffic and the CTUIR transit system, making evacuations difficult (CTUIR Hazard Mitigation Plan, 2016).”

Contemporary CTUIR communities rely on rigid buildings and shared transportation

routes that need to be constructed and maintained. It is in these buildings where the Tribe lives, prepares First Foods, celebrates Feasts, and governs itself. And it is by using these roads and infrastructure that Tribal Members are able to access their Treaty Rights.

These components of infrastructure will face challenges from changing climate conditions, particularly from extreme heat and flooding.

1. Increased Severity and Frequency of Storms

Seasonal flooding events will increase in magnitude, though large annual variability will exist. Flooding and associated storms are likely to increase damage to homes and buildings, cause roadway blockages, and down power lines.

20-30% increase in 100-year flood events by 2040 (Tohver and Hamlet, 2010) as seen in Figure 3C.1 (page 108).

2. Increased Vulnerability of Transportation Infrastructure

Transportation to cultural sites and harvest opportunities to exercise Treaty Rights require access roads for Tribal Members. USFS low traffic roads in forested lands are especially necessary for First Foods access. Many stream-adjacent sections of these roads will be threatened by flooding.

Roads in the Powder and Burnt River basins, southwestern Malheur River, Grande Ronde River, and southern Eagle Caps Wilderness have 20-30% + risk from floodwaters; least threatened is the Wenaha-Tucannon Wilderness, with 10% or less of risk change, as seen in Figure 3C.2 (page 109).

“To the Indian, there was only one place where he belonged—in his homeland made sacred by the ageless sleep of his ancestors, made fruitful by the spirit of his children yet unborn. ”

~Maudie C. Antoine, CTUIR BOT Chair (1955)

3. Increased Stress on Indoor Air Filtration Systems

Stress on air filtration systems for facilities of all sizes will increase as particle pollution from many sources increases. Indoor HVAC and filtration systems are likely to need to be upgraded for changing climate demands.

During nearby smoke events, **use of HEPA filters provides 58% reduction in particle exposure compared to non-filtered indoor conditions** (Barn et al, 2008), as shown in Figure 3C.3 (page 111).

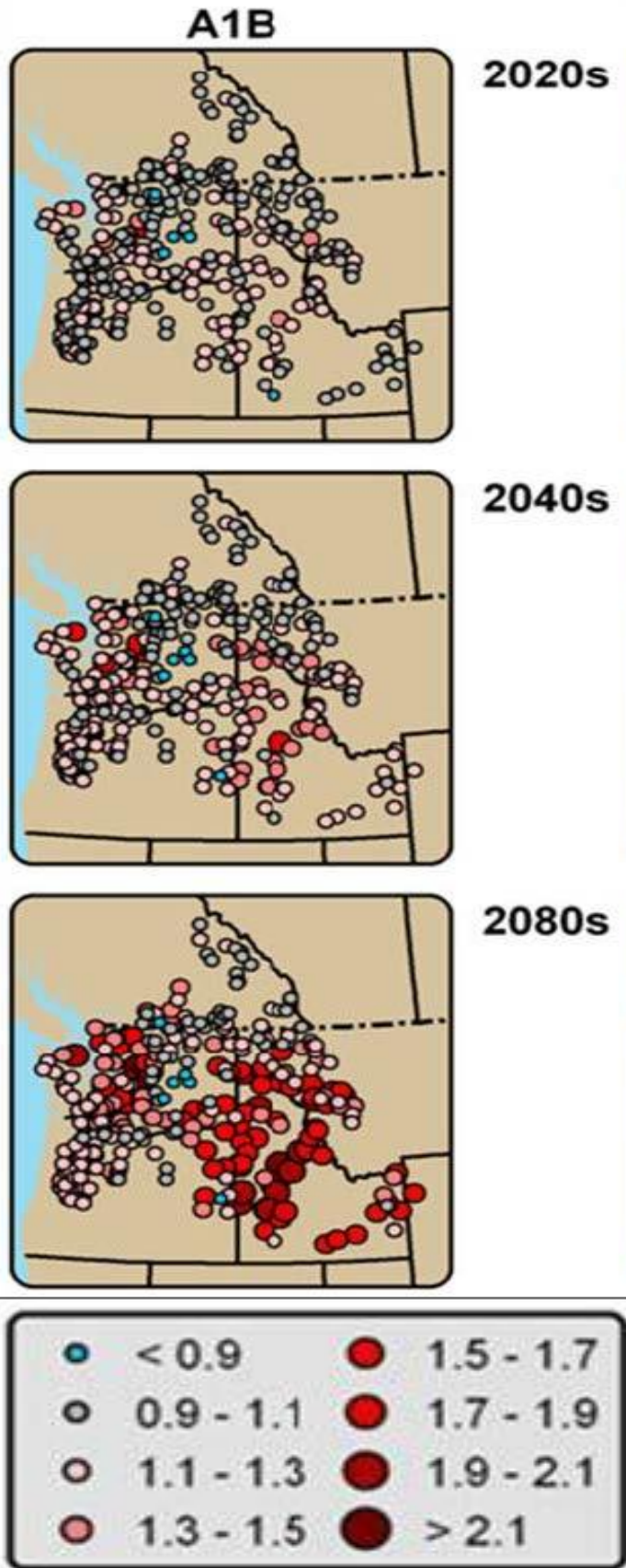
4. Development in the Wildland/Urban Interface (WUI)

Exacerbated by population growth, development in potential suitable First Foods habitat is likely to increase. Development can restrict the access that Tribal Members have to traditional harvest lands, and roads cause migration challenges to wildlife.

At high traffic, **deer are 500% more likely to be present, while elk are 300% more likely to move away from these areas.** At very low traffic, **elk are 100% more likely to move towards small roads, and deer are almost 200% more likely to not occupy these same locations** (Wisdom et al 2017), as seen in Figure 3C.4 (page 112).

Climate Impacts for Physical Infrastructure

Figure 3C.1: Ratio of 100-Year Flood Statistics into the Future



1. Increased Frequency and Severity of Seasonal Storms

“Constraining [river] high flows concentrates stream power (and energy to move sediments) within the main channel, resulting in an incised channel with faster flows. Such altered hydrologic and geomorphic conditions reduce the range of habitats with depth and flow conditions suitable to native riverine species and promote channel incision, further diminishing habitat connectivity (Umatilla River Vision, 2011).”

Essential infrastructure located in floodplains restricts the natural function of the waterway, as well as putting this infrastructure at risk from increased magnitudes of flooding.

Figure 3C.1 provides an illustration of how these waterways are projected to change in flooding magnitude as a percentage of historic 100-year flood levels, into the 21st century under Scenario A1B.

- Colored dots of various sizes mark the expected change in flooding at three different points: by 2020, 2040, and 2080. These dots show small changes as blue dots, and larger changes as increasingly dark red hues.
- These changes are calculated as the percent of a 100-year flood event; for example, blue dots indicate 90% of a 100-year flood event, which is actually a reduction in flooding. Conversely, 1.7-1.9 (midsize red dots) correspond to 170-190% of a 100-year flood event, making this a 41-47% increase in flood magnitude.
- Much of the CTUIR Ceded lands are projected to **experience 20-30% increases in flooding by 2040, and 33% and greater increase by 2080.** Parts of Idaho that are likely to become suitable First Foods habitat are projected to experience 47% and higher increases in seasonal floodwaters (Tohver and Hamlet, 2010).

Overall, it can be expected that when flooding occurs, the magnitude of the volume of water will exceed previously anticipated levels, and can threaten the structural integrity of existing infrastructure. These expected increases in flood volume must be incorporated into planning and construction of new projects.

CTUIR’s community experienced an example of this impact in February 2020, when flooding inundated numerous homes, swept vehicles and debris into rivers, and destroyed Thornhollow Bridge, as well as a number of other river-adjacent roads and railways, which reduced transportation accessibility and emergency evacuation options. These kinds of events will be increasingly more frequent in the future, and watershed floodplains will expand as a result of increasing flood magnitudes. Vulnerable and essential infrastructure planning needs to include climate change projections in planning for new and existing infrastructure.

(Credit: Tohver and Hamlet, 2010)

Gaps in Knowledge/Data/Policy:

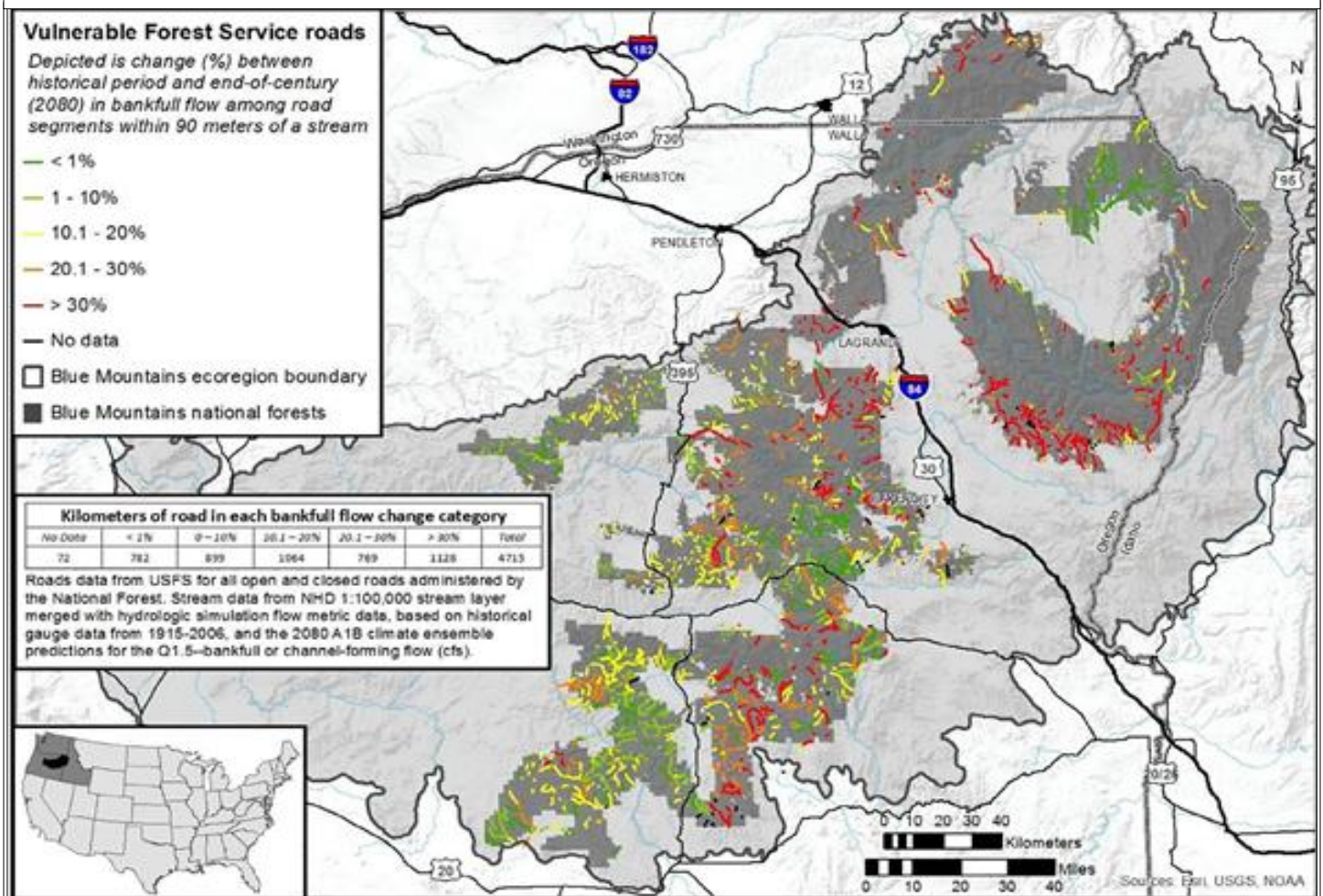
- Data on expansion of floodplains in response to increasing magnitude and coordination with Federal Emergency Management Agency (FEMA);
- Changes in wind activity, intensity, and direction as it is part of storm intensity.

2. Increased Vulnerability of Transportation Infrastructure

“The UIR and Umatilla County rely primarily on automobiles and trucks as the main sources of transportation. Maintaining the highway and road system and to the reservation and within the reservation is essential to the area economy and general welfare of the residents of the UIR... Other transportation modes that exist on the UIR are Union Pacific Railroad lines, pipelines used for transporting natural gas, and high voltage electrical lines used by the Bonneville Power Administration to transport electricity (CTUIR Hazard Mitigation Plan, 2016).”

First Foods exist frequently in locations where Tribal Members must travel to in order to reach harvest opportunities. Tribal Members travel on roads and cross bridges to reach these locations, and this transportation infrastructure is often located over and adjacent to waterways. Forest Service roads are often gravel, and thus can be at high risk of eroding when high

Figure 3C.2: Percent Change in Bankfull Flow by 2080 Compared to Historic



water events inundate them seasonally.

Figure 3C.2 is a map of three National Forests within CTUIR Ceded lands, and shows U.S. Forest Service roads that are close to waterways and vulnerable to flooding.

- Within this map, green roads are found to be least impacted (10% or less of change), while yellow and orange roads are moderately impacted (10.1-30% threatened), and dark red roads are severely impacted at 30% and greater increase in risk to infrastructure.
- In this map, many of the roads in lower elevations are likely to see small to moderate increases in risk, such as in the **John Day basin, Middle Fork John Day River, Silvies River, and western Umatilla National Forest near Heppner** were estimated at **1-20% increased risk (Clifton et al 2018)**.
- Other regions will experience higher rising risk as seasonal snow melts more quickly, including regions like **Powder and Burnt River basins, southwestern end of the Malheur National Forest and Malheur River, Grande Ronde River, and southern Eagle Caps Wilderness** with **20-30% and above risk (Clifton et al 2018)**;
- Lowest increase is expected in the **Wenaha-Tucannon Wilderness** with **10% or less** of change.

Roads are used by Tribal Members to access First Foods harvest opportunities, and U.S. Forest Service roads especially assist hunters and gatherers to reach remote locations where First Foods thrive. The existence of many of these roads next to rivers and streams also creates barriers to implementing Umatilla River Vision strategies, but are necessary to reach historic and existing locations for many First Foods.

Tribal community prioritization of roads under risk of being destroyed by flooding should be conducted to understand which roads are at risk and which are worth being reinforced and updated where possible. (Credit: Clifton et al 2018)

Gaps in Knowledge/Data/Policy:

- How Tribal community members value specific roadways and access points, and where there are



Thornhollow Bridge on the Umatilla Indian Reservation was damaged by the February 2020 flooding. Note the buckled concrete in the bridge center.

- roads that create problems or hazards;
- Landslide potential and how wildfire and prescribed burning may factor into sediment movement after disturbance, and with heavy precipitation.

3. Increased Demand on Facility Indoor Air Filtration Systems

Facilities, homes, and service infrastructure are an integral part of modern Tribal life, and CTUIR has planning in place to maintain and improve these in its Comprehensive Plan. However, much of previous planning has been done using historic estimates of weather patterns and extreme events. Climate crisis impacts will change seasonal conditions and increase regular maintenance burdens, as well as increase risk of extreme events that require emergency response.

Most Tribal facilities are likely to need upgrades in air filtration as a result of increasing wildfire smoke, dust from drought conditions, expanding pollen potency and season, and ozone created by extreme heat events.

Figure 3C.3 shows the change in air quality between filtered and unfiltered conditions during wildfire smoke inundation events.

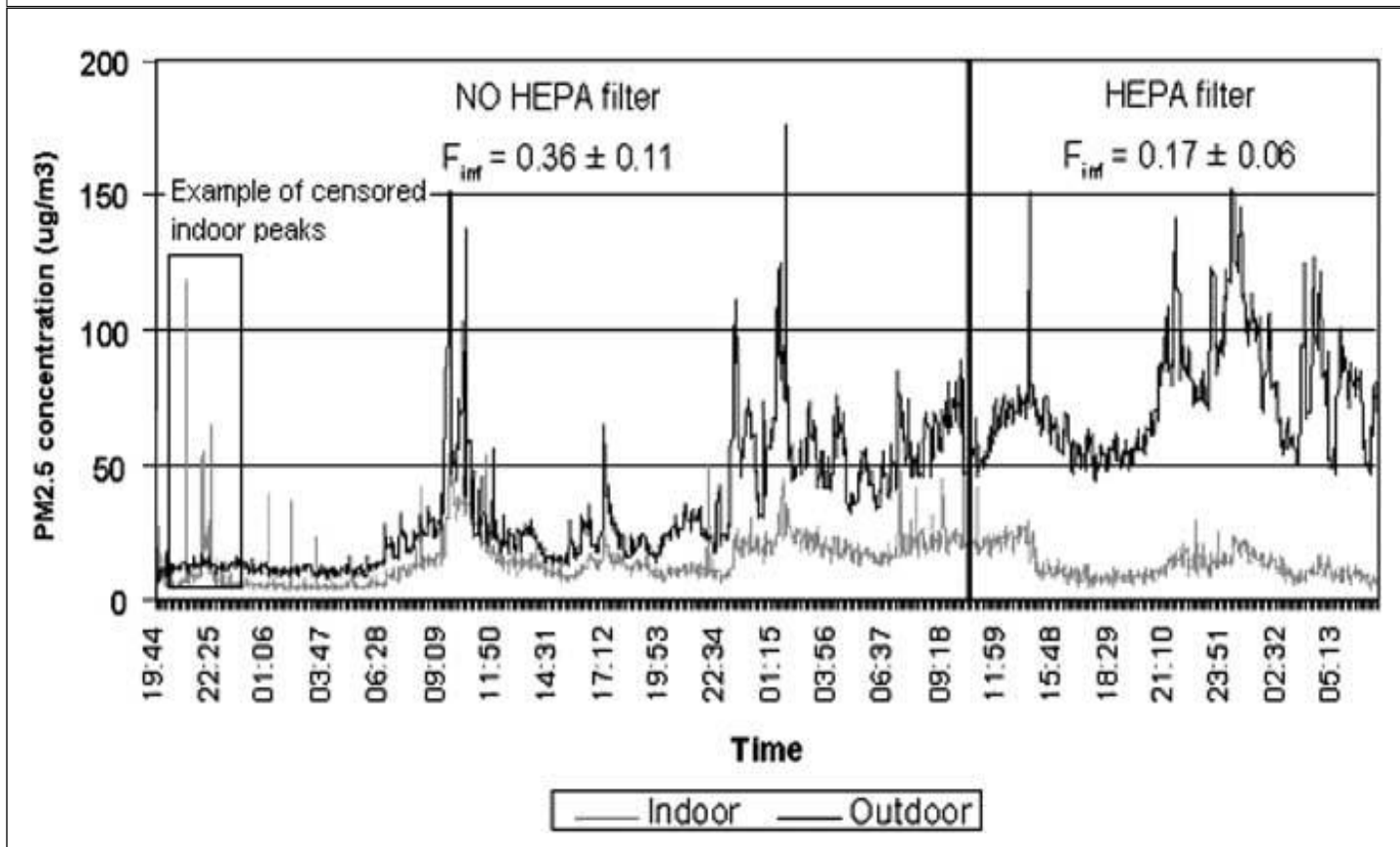
- This time chart shows a 2-day period of indoor air quality in a residential house during a summer 2004 wildfire event in British Columbia, measured as Particulate Matter (PM) 2.5 present over time. The light gray line represents air quality sampling within the home, while the dark line shows air particulate matter outdoors.
- The left side of this diagram shows particle pollution indoors before filtration equipment was implemented, and can be considered an accurate example of homes and buildings that lack robust air filtration capacity. On the right is the impact that HEPA-grade air filtration has on wildfire particle pollution.
- This illustrates intrusion of smoke into housing without HEPA filtration can be 70-100% of outdoor air quality (Barn et al 2008). This means that indoor air is close to, or the same as, conditions outdoors.

- Use of the HEPA filter **improved indoor air quality 58% over outside air** during the wildfire, showing the difference a filtration system can make in the air quality and health of people over time.

These findings call into question common public health recommendations to “shelter in place” (remain inside buildings) during poor air quality events, as this recommendation inaccurately assumes that most facilities have adequate filtration capacity. Future conditions will create increasingly frequent poor air quality events, and many homes are not adequately equipped with air filtration to protect residents.

Upgrading and maintaining facilities is a costly undertaking, but planning for improvements and upgrades now could help alleviate some of the funding burden in future years. Increasing awareness poor air quality effects, improving understanding of current smoke intrusion into facilities, and empowering communities around air quality decision making can improve agency in adapting to this climate impact.

Figure 3C.3: Indoor Air Quality Improvements from HEPA During Wildfire Event



(Credit: Barn et al, 2008).

Gaps in Knowledge/Data/Policy:

- Infiltration rate of smoke into CTUIR facilities and housing;
- Rates of ozone pollution that exist around Tribal communities and population centers.

4. Development in the Wildland/Urban Interface (WUI)

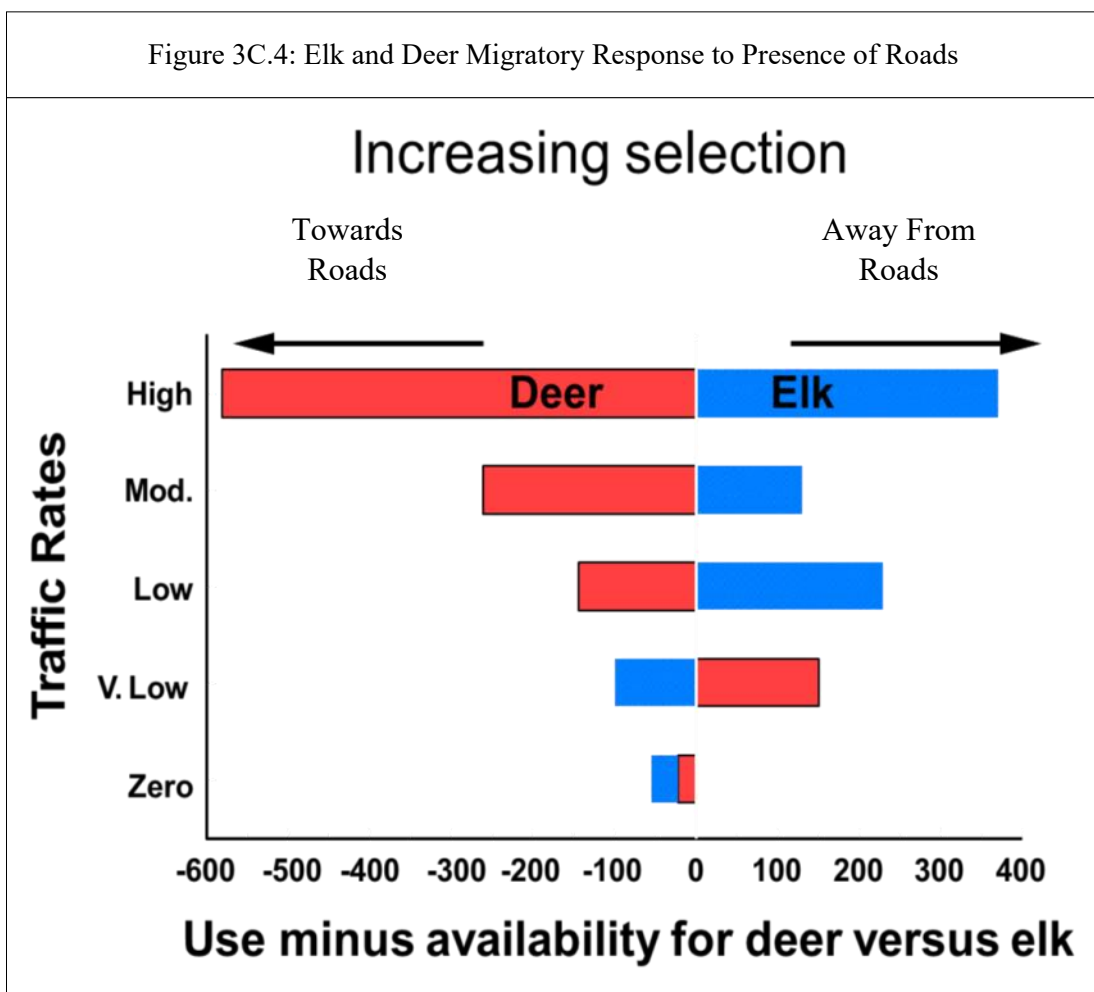
“Roads are well known barriers to the movement of elk and deer. Roads are thought to be a driving factor in determining elk distribution across seasons and landscapes. Elk avoid roads resulting in distribution shifts of populations away from roads and concerns about increased flight responses and associated energetic costs, reduced foraging time and reducing the total amount of effective habitat. Roads also facilitate other human activities such as recreation, which can affect habitat use and behavior of Big Game (First Foods Upland Vision, 2019).”

Infrastructure often creates access issues for

success and harvest of First Foods, and the climate crisis will find those conflicts intensifying. Development in the WUI creates many challenges that will be made worse by changing conditions: highways are migration barriers to many plants and animals, electrical transmission lines are strung through forests that are experiencing more intense pest and wildfire pressure, and houses decrease agency capacity to use prescribed fire as a management tool while creating additional structures that need to be defended by wildland firefighters.

Figure 3C.4 shows the results of an experiment the Starkey Experimental National Forest, located within the CTUIR Ceded lands. Its goal was to monitor the movement patterns of elk and deer as compared to the traffic rates of roads in their migration territory.

- This chart examines the relationship between elk and mule deer dynamics in the presence of variable road traffic and each other. Bars show the magnitude of migration (animal “use” of space subtracted by the availability of habitat) towards or away from roads of different sizes, for elk and deer respectively.



- Blue bars represent elk migration, while red bars show movements of deer, both in response to the presence of roads. Migration towards roads is demonstrated by negative values, while away from roads is designated by positive values.
- In high traffic situations, such as large highways through forested lands, **deer are 500% more likely to utilize habitat near roads, while elk are over 300% likely to move away from these same roads.** This pattern of distribution is similar with moderate traffic (such as paved non-highway surface streets),

where deer are roughly 300% more likely to occur near these roads, and elk 150% more likely to move away from these kinds of roads. At low density traffic, such as along graveled Forest Service roads, the pattern still remains, with deer 150% more likely to use those spaces, and elk much more likely at 250% to move away from those roads (Wisdom et al 2017).

- At **very low traffic volumes**, such as un-graveled Forest Service roads, and ATV, horse-, and hiking trails, the pattern is reversed, finding **elk 100% more likely to move towards those small roads, and deer almost 200% likely to not** occupy those same spaces. No roads was measured to affect the availability of both deer and elk, with elk 50% more likely to move towards these spaces, and deer only 25% more likely (Wisdom et al 2017).



Roadways facilitate Tribal Member access to First Foods harvest while also presenting a migration barrier to these species. Pictured is a Big Game caution sign at Hanford Nuclear Reservation, installed after numerous vehicle strikes of elk and deer that are populous at the site.

- This study shows that **elk are prone to move away large roads with high traffic, while deer are more likely to move away from areas where elk exist at high densities.**

While traffic presence is not strictly a climate impact, human development in the WUI affects species habitat health, connectivity, and the ability to migrate. Such knowledge about Big Game response to traffic intensity is helpful when planning for new and existing infrastructure in the light of the climatic changes.

Population growth projections used in the CTUIR’s Hazard Mitigation Plan (2016) predict 7.5% growth rate for both CTUIR and Umatilla County (CTUIR Hazard Mitigation Plan, 2016).

This estimate is without any kind of anticipation of regional climate migration, as magnitudes of which are difficult to predict. As populations grow over time and with climate-induced migration, more pressure will be placed on developing in the WUI.

Prioritizing either elk or deer success in certain locations can be assisted by the placement of roads and trails that support access to these First Foods, and infrastructure planning should consider these kinds of First Foods migration and habitat requirements in the siting and maintenance of structures.

Gaps in Knowledge/Data/Policy:

- Migration pathways and population habits that could assist infrastructure adaptation planning.

Adaptation Goals for Physical Infrastructure

A. Identify Ongoing and Emerging Hazards and Opportunities on the UIR and CTUIR Ceded Lands.

i. Coordinated Mapping of Biological and Physical Hazards

“An essential component of the Umatilla Indian Reservation’s Hazard Mitigation Plan is the identification of natural and man-made hazards that present potential risks to lives, property and the natural and cultural resources of the Reservation. The purpose of this section is to identify hazards that have the potential to cause injury or damage and evaluate whether or not they present a realistic threat to the residents of the Umatilla Indian Reservation (UIR). Each of these hazards is analyzed to determine the level of risk that each hazard presents (CTUIR Hazard Mitigation Plan, 2016).”

Flooding and wildfire cause many different emergencies for the natural, built, and social environments.

Short Term:

- **Perform an inventory of existing and emerging disaster needs.** This may include natural threats like landslides and slumps, threats to the built environment such as septic tank seepage from flooding, or threats to social systems such as “shelter in place” support for elders and others isolated by extreme heat or smoke events. This exercise could be done for just the UIR, or in collaboration with other entities across the CTUIR Ceded lands and beyond, and should build on existing documents like the Hazard Mitigation and Emergency Operations Plans.
- **Fund and staff dedicated hazard mitigation planning positions** to build capacity for proactive and reactive emergency services. As a potential position within Tribal Planning Office (TPO), such a position could work closely with Public Safety, Dept of Child and Family Services (DCFS), and other programs that respond to community need before, during, and after a disaster event. This could include working with community members proactively to put safety and preparedness precautions in place.
- **Inventory and map current and emerging areas of concern for transportation infrastructure** on UIR and for Tribal community members who live off reservation. These might include areas of pooling water, roads and bridges threatened by flooding, or transit stops that are at risk of heat and smoke exposure.
- **Inventory and map current and emerging areas of concern for communication networks** on the UIR and for Tribal community members who live off reservation. These might include points of vulnerability due to shared services infrastructure (powerlines, water mains, etc). This could include an assessment of insufficient services like internet access for those at dispersed living sites like Gibbon and Thornhollow, as well as an chance to highlight opportunities for connection like the Cay-Uma-Wa Camp Crier online communication application; see Ch 3F pages 241-244 for additional detail.



Previous flooding events like the one on the Umatilla River in Feb 2020 have revealed where regional infrastructure is vulnerable to future disaster events.

Long Term:

- **Update existing plans and codes using climate projections** and data modeling to anticipate climate changes to flooding and other climate-intensified disasters. This is already beginning with the FEMA remapping of the Umatilla River floodplain in 2022. Some of these changes will need to involve federal agency participation, and potential acts of legislation to be implemented.
- **Continue to update CTUIR Hazard Mitigation Plan** with community engagement on emergency response needs as these change. Currently this plan undergoes revision on a 5-year interval with a new version expected in 2022. Each new version of this plan has incorporated elements of climate impacts within its scope, though had yet to incorporate specific climate projections and data.
- **Update transportation and communications planning to incorporate changing climate conditions** and Tribal community needs; this process is going to be starting with the 2022 Transportation Plan update. A new version of this plan could incorporate climate impact projections to better align strategic planning and benchmarks with anticipated future conditions.

ii. Community Capacity for Built Systems Management

“Planning itself is an ongoing attempt to guide future development or redevelopment, solve problems, address future needs, and create opportunities to enhance community life, the local economy, and environmental quality (CTUIR Comprehensive Plan, 2010).” Planning invites the community to share perspectives and skills, as well as express unmet needs and visions for the future.

Short Term:

- **Facilitate community identification of traits of a flexible transportation system**, for Kayak and other services, such ability to recognize external changes and threat (responsiveness), and take the appropriate action (competency and organic organizational structure). These community-identified priorities and strategies could assist in long-term transportation planning that accurately anticipates the current and future needs and gaps in service for riders and operators.
- **Expand education and skill-building around residential emergency response**; this is likely to include residential well testing and treatment protocol, septic tank inventory and installation of risers, implementing home fire breaks and fire resistant building materials and landscaping, performing assessments of built infrastructure regularly, and preparing relevant insurance and ownership documents in the event of an emergency. Additional planning could assist in proactively migrating vulnerable homes and infrastructure out of the floodplain and assistance in filing necessary claims on damage and loss financing.

Long Term:

- **Develop community response mapping tools** where Tribal community members can inventory and identify locations where problems exist, and where there are new issues emerging. Facilitating an online reporting tool as well as hosting periodic discussion groups could empower community members and provide valuable information sharing on issues as they arise.
- **Facilitate improved community aid capacity** to assist with property disaster risk assessment, disaster volunteer responder coordination, documentation of damage post-event, and with meeting



insurance claims and requirements. Government staff capacity can only go so far, and empowering the Tribal community to be proactive, reactive, and supportive of emergency coordination will improve CTUIR’s overall ability to respond quickly and effectively to disasters as they occur. Additional guidance and community coordination can be included in future versions of the Emergency Operations Plan (EOP, 2016); see EOP 3.3.3 page 67 for additional detail.

B. Anticipate Changing Community and Climate Demand on Facilities for Investment Planning

i. Upgrade CTUIR Facility and Residential Air Filtration Capacities

In recent summers, all CTUIR facilities have struggled accommodate the sharp increase in smoke pollution from wildfires, particularly ones burning in the Willamette Valley and Columbia River Gorge. These fires will be a regular part of summer in the future, as well as the increasing prevalence of other climate-related air pollution sources like dust, pollen, and ozone. While upgrading facilities can be expensive, it is cost effective long term to begin those upgrades as soon as possible.

Short Term:

- **Implement community initiatives to improve residential exhaust fans** use and understanding, to mitigate smoke, mold and mildew. CTUIR Housing has worked with residents of Tribal housing to understand the

importance of utilizing exhaust fans to remove particle pollution and moisture from inside homes to prevent illness, as well as other strategies to improve air circulation and quality.

- **Migrate Heating, Ventilation, and Air Conditioning (HVAC) and central heating/cooling infrastructure** from foundations or subbasements if affected by flooding, especially in Tribal housing. CTUIR Housing Department has been at the forefront of this work; Mission area housing has long been seasonally affected by groundwater seepage that inundates housing foundation and causes maintenance problems. In response, Housing has implemented a project to migrate essential ventilation system equipment from housing foundations to attics, in an effort to reduce maintenance issues caused by flooding.



Mission area housing has experienced inundation from rising groundwaters, also known as a spring, which is located in the floodplain of nearby Mission Creek.

Long Term:

- **Upgrade Tribal facility HVAC systems** to use Minimum Efficiency Reporting Values (MERV) 13 grade filtration at least. This will likely require a systems revision that could be lengthy and costly. Anticipating this need early can assist in planning for this large cost burden and there are many interim steps that can be taken, such as installing independent air ventilation systems in buildings. This was done during the height of the Covid-19 pandemic for the Head Start and Afterschool Programs within the CTUIR Department of Education.
- **Identify barriers to indoor air quality health** that the community experiences, and develop strategies to overcome these barriers. These might be

cost barriers around equipment or energy use, infrastructure barriers like home or apartment upgrades and eligibility of assistance programs due to property ownership status, among others.

- **Assess the needs of extremely vulnerable community members specifically**, including elders, outdoor workers, and unsheltered community members; these needs are likely to be different than other age groups, occupations, and lifestyles. Prioritizing these groups in adaptation response guarantees that all peoples' needs are being considered.

ii. Water Reclamation and Management Infrastructure

“The First Foods-focused mission highlights direct linkages between the ecological health of the Umatilla River and the health and well-being of Umatilla Tribal Members. Degradation of the river, water quality, and associated ecological processes results in the loss of traditional Tribal foods. This loss of food resources is linked to increasing occurrences of health issues (Umatilla River Vision, 2011).”

Waste- and stormwater are underutilized opportunities for water conservation. Sewage and storm water reclamation could provide additional non-potable water supplies for appropriate to non-consumptive uses in order to reduce future demands on finite freshwater sources.

Short Term:

- **Improve assessment and treatment of residential septic and well systems** to provide skill building to families, and prevent leaching or other contamination of groundwater. As incidences of flooding increase, residents with isolated well and septic systems need to understand and be

aware of hazards and mitigation strategies that will minimize harm to human health.

- **Support community reporting and guidance on planning** through an interactive mapping and comment collection. An example is the 2021 Capital Improvements Plan update; this visioning exercise is being conducted by the Tribal Planning Office (TPO) to engage the community in planning for the future of this space. An ArcGIS webmap tool has been used to gather ‘real time’ feedback from community members, though access to this portal is not equitable for those who lack internet access or access to web navigation services. <https://ctuir.org/news/input-on-capital-improvement-projects/>

Long Term:

- **Continue to fund, implement, and plan the proposed CTUIR wastewater treatment plant**, and expand on TPO and Public Works feasibility studies about membrane-bioreactor (MBR) treatment technology. This is a multi-million dollar proposed facility which will require time to secure capital, and permit plans to build. There are intermediate steps such as feasibility studies and water use information/voluntary metering initiatives that can be implemented in the shorter term.
- **Develop and implement water recovery and graywater use strategies**, including graywater capture approaches that sequester water for landscape and irrigation purposes; reclaimed water is often not safe for human consumption, but could be used for non-food irrigated landscapes like the Wildhorse Resort and Casino Golf Course, CTUIR governance facilities



campus greenspaces, and for spaces of gathering like the July Grounds, among others. More research on potential impacts to health would be needed.

iii. Intentional Water Infiltration and Conservation Strategies

Water is precious, and conserving cold, clean water will be essential. Strategies to sequester winter precipitation and high flow can be natural, behavioral, and engineered, and these strategies can be combined for effective conservation.

Short Term:

- **Inventory and map locations of seasonal water inundation** from groundwater and surface water sources across UIR and in the Mission community. Some of this assessment has already been done as part of the CTUIR Hazard Mitigation Plan (2016), but a dedicated mapping effort could yield updated and additional information, as well as empower and engage the Tribal community in planning.
- **Support and implement Native and drought-tolerant plants** in landscaping, at home, within Tribal government and community development, and across the UIR. Much of the CTUIR Nixyaawii/Yellowhawk Campus, Coyote Business Park campuses, and Wildhorse Hotel and Casino complex are landscaped with native vegetation that requires minimal seasonal irrigation. Expanding the use native plants for landscaping with CTUIR entities, across the UIR, and around the region, and partnering with the DNR Tribal Native Plant Nursery would reduce summer irrigation demand from nonfood sources.



Greenspaces and other permeable surfaces like the engineered wetlands outside the Yellowhawk Tribal Health Center (pictured) help stormwater be infiltrated rather than pooling.

- **Implement engineered storage options like bioswales and other strategic landscape management practices**, especially where it preserves built systems integrity. Many of these practices are rooted in Indigenous knowledge and are often labeled “permaculture” or “restoration agriculture,” taking advantage of natural ecosystem function to capture heavy precipitation and facilitate its infiltration into the soil.

Long Term:

- **Continue to relocate critical and new infrastructure out of climate-forecasted floodplains.** Past migrations include: Nixyaawii Governance Center (NGC), Yellowhawk Health Center, Nixyaawii Community School (NCS), and the new Nixyaawii Community Neighborhood development. Other new developments are planned for the future. Infrastructure that comprises the Mission area and Mission Market are still located in the Umatilla River floodplain and would require capital investments to relocate.

- **Install permeable pavement in new and revitalized development** (where possible) to reduce the likelihood of roadway flooding and increase soil water storage. ‘Permeable pavement’ is constructed to provide structural paved surfaces that can rapidly percolate water through its surface and distributed into the substrate below. Engineering paved surfaces that can redistribute stormwater to adjacent greenspaces would assist in capturing winter water; see Chapter 3A pages 60-61 for additional detail.

- **Develop natural storage options like wetlands** where feasible, and determined by the Tribal community. Wetlands and ephemeral streams are natural deposition areas for seasonal flood waters, and the inundation of these storage ecosystems provides water filtration and cooling outcomes for water through wetland soils. These ecosystems also provide excellent habitat for First Foods species, especially those that have been impacted by the regional draining and destruction of historical wetlands.

C. Develop Sustainable Housing and Walkable Communities

i. Implement Land Development that Facilitates Non-Carbonized Living

“The Reservation Boundaries were under attack even before it was surveyed. Public meetings were held in La Grande, Pendleton, and Walla Walla in the late 1860's to remove the Indians from the Umatilla Reservation. The settlers had discovered that Indian lands were capable of producing wheat and the mountains were good for livestock grazing. Roads and trails were utilized by the whites who were constantly encroaching on reservation lands (CTUIR Comprehensive Plan 2010).”

Living in disconnection with land, water, and foods has been a large driver of the climate crisis. Roads and vehicular transportation that burns fossil fuels have been instrumental in this disruption. Reviving and revising ways of living that create greater connection with natural resources and community will be essential in reducing carbon footprints.

Short Term:

- **Incentivize personal choices that**

reduce carbon demands. Examples include reduced mandatory minimum off-street parking, robust public transit services like Kayak Public Transit, and street tree and landscaping policies that prioritize native and drought-tolerant vegetation. This may require securing funding and Tribal government staff capacity to organize and implement such incentive projects, though many could be paired with surveys to the Tribal community on how best to engage around issues and barriers experienced by communities.

- **Update relevant services plans to assess emerging community needs.** An example the forthcoming update to the Transportation Systems plan, which will engage the tribal community how transportation needs are changing. Development of Tribal long-term plans typically involve some level of engagement with CTUIR official committees and commissions, though outreach to the broader Tribal community depends on the individuals and programs administering this process. Expanding and explicitly planning for broad CTUIR community engagement in planning could strengthen planning efforts.
- **Design and implement communal living spaces, greenspaces, and gardens** that allow for Tribal community members to create abundance collectively. Consciously including areas for people to gather and share knowledge, tools, supplies, produce, services and aid, and many other things, will create opportunities for building resilience through connection.

Long Term:

- **Prioritize compact and multi-use zoning for new Tribal development** (where possible). An example is the



new Nixyaawii Community Neighborhood (also known as Bowman South) subdivision development, zoned in a way as to reduce the need for vehicular travel by placing residences close to current and future employment and services. This should facilitate the development of a diversified walkable community where people are able to live near work and commercial opportunities.

- **Develop, fund, and implement non-motorized transportation opportunities** like walking, biking, and horse trails, particularly to areas of employment, business, and services, like the 2022 Walk Routes to School grant from ODOT to implement a walking path from the Mission area/July Grounds to Nixyaawii Community School to assist students getting to school in a safe and healthy manner. As more community infrastructure is re-located out of the Mission Creek floodplain, there are additional opportunities to ensure these new developments are navigable through non-carbonized means.
- **Continue to fund, expand, and improve CTUIR Kayak Public Transit** vehicles, staff, systems, outreach, incentives and costs assistance, among other needs, for the award-winning rural public transit system.

ii. Expand Localized Economy and Opportunity

Hazardous conditions do not necessarily become disasters, however climate change will act as a “threat multiplier” that will increase the likelihood of overlapping hazards becoming emergency situations. Some hazards are man-made: lack of evacuation routes, barriers to accessing aid, and unavailability of necessary items and equipment are components that can turn hazards into disasters. Supply chain issues are likely to continue and worsen into the future due to globalization, and increasing frequency of natural disasters. Diversifying and localizing materials and



Recent Tribal housing developments like Huckleberry Court (pictured) have been built to include energy efficiency measures that can reduce energy demands and improve standard of living.

services sourcing will fortify Tribal and regional communities against disruption.

Short Term:

- **Conduct community kitchen feasibility assessment to assess infrastructure and capacity needs** in constructing and operating a certified commercial kitchen with access for the Tribal community. Such a facility could greatly expand the capacity of the CTUIR community to provide local food, safe processing options, diversified economic initiatives, and opportunities to share knowledge and skills in a way that builds resilience. See Ch 3F page 232 for additional detail.
- **Identify essential manufacturing or production processes likely to be disrupted** by future global instability, and incorporate plans to mitigate for these impacts. Recent years have demonstrated that supply chains that source globally are guaranteed to experience disruptions as extreme weather events become frequent. Improving local and regional sourcing could mitigate for these impacts, and identifying essential goods, components, components, and services that have been affected by recent supply chain disruptions would provide a roadmap for where needs and supplies are vulnerable. See Ch 3F 227-228 for additional detail.

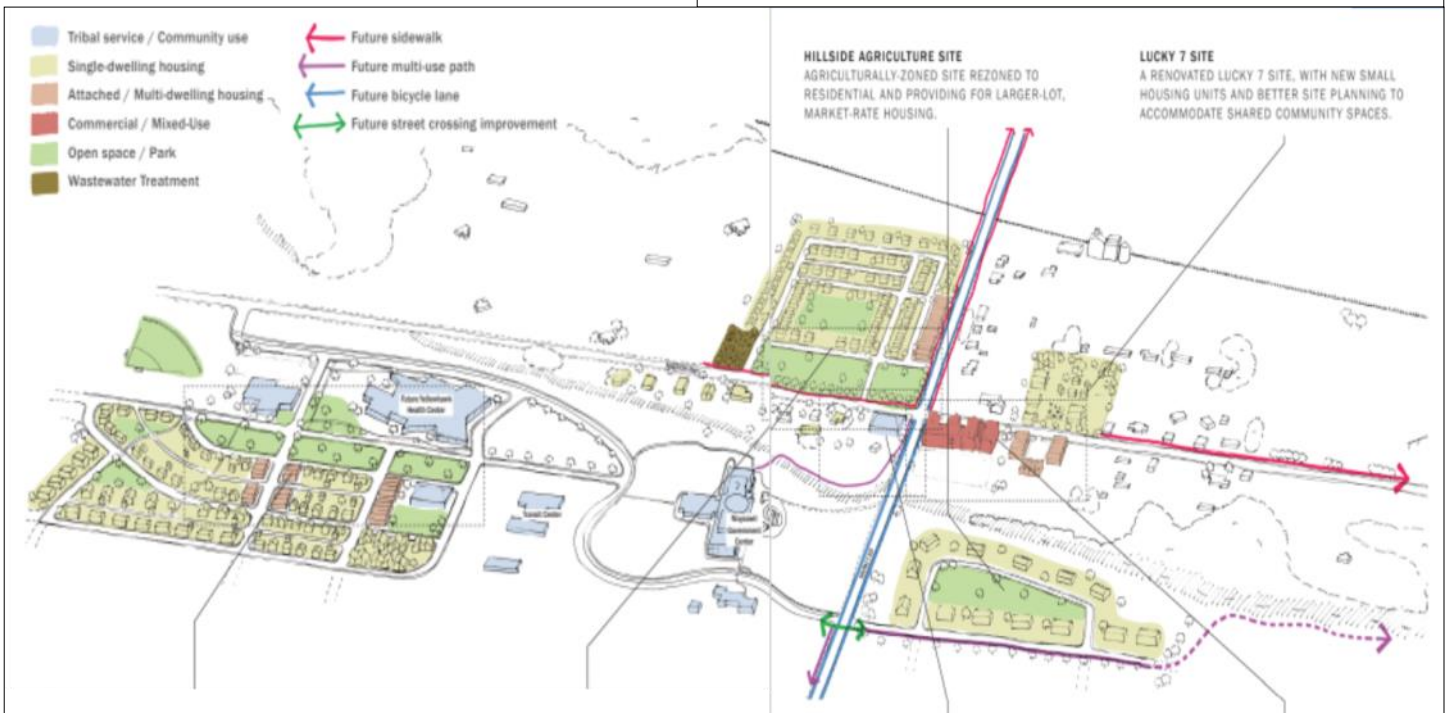
Long Term:

Prioritize or strengthen materials sourcing from local/regional locations (as is conditionally appropriate) for construction or services demands, and identify potential alternatives if able. An existing example is local procurement of gravel and construction materials for Tribal development projects from American Rock asphalt manufacturers on the Umatilla Indian Reservation (UIR). While an extractive industry like construction materials mining creates harms to environmental conditions, sourcing such materials regionally allows for CTUIR to have a role in regulating activities, as well as mitigating for global instability.

- **Continue to build transportation networks and partnerships across the larger region** to improve access and connectivity, and to alleviate barriers identified. Kayak Transit already extends across the CTUIR Ceded lands and provides free transit to riders within this area. Municipalities often have their own smaller transit services that operate much smaller routes, and greater collaboration between these systems could improve public transit conditions for all.



Tribal Planning Office (TPO) has been planning for changes to the July Grounds area of the Mission Community, and has used outreach and online mapping to engage the CTUIR community in what this will look like; pictured is one possible plan proposed by TPO .



CTUIR TPO regularly engages the Tribal community in visioning for the future. Pictured is from the Mission Community Master Plan that plans for future developments of the CTUIR Tribal community.

Measuring Success and Gaps in Physical Infrastructure Adaptation

How Do We Measure the Success of These Adaptations?

- **CTUIR Land Development Code** (revised 2021): many regulations, permitting, and zoning requirements and restrictions are outlined.
- **Comprehensive Plan Objective 5.5.1:** Reserve adequate capacity in Tribal sewer and water systems for future Tribal use and development (see Comp Plan page 76 for benchmarks);
- **Comprehensive Plan Objective 5.5.2:** Develop land use policies and Land Development Code regulations that assure the UIR is a sustainable community (see Comp Plan page 76 for benchmarks);
- **Comprehensive Plan Objective 5.9.7:** Seek to achieve carbon neutrality in all new housing construction by incorporating energy efficient design and construction in Tribally funded housing and by extending technical assistance and incentives where possible to individual Tribal Member home construction. (see Comp Plan page 97 for benchmarks);
- **Comprehensive Plan Objective 5.13.5:** Provide transportation opportunities for Tribal citizens and other Reservation residents that do not drive. (see Comp Plan page 117 for benchmarks);
- **Comprehensive Plan Objective 5.13.6:** Provide transportation facilities for non-motorized transportation, including pedestrians, bicycles, and horses (see Comp Plan page 117 for benchmarks);
- **Comprehensive Plan Objective 5.13.5:** Provide transportation opportunities for Tribal citizens and other Reservation residents that do not drive. (see Comp Plan page 117 for benchmarks);



Flooding like the February 2020 event illustrates the vulnerability of infrastructure, like the Walla Walla River running through municipalities such as the City of Walla Walla pictured here.

- **Comprehensive Plan Objective 5.13.10:** Provide transportation opportunities that conserve energy and money, and reduce carbon emissions. (see Comp Plan page 117 for benchmarks).
 - **CTUIR Hazard Mitigation Plan (2021) Section 3:** Hazard Identification and Risk Assessment Results (page 68-190);
 - **CTUIR Hazard Mitigation Plan (2021) Section 4:** Hazard Mitigation Strategy (page 192-212).
 - Adequate housing availability and suitability for tribal members and community;
 - Upgrading Tribal housing and facilities to respond to smoke and flood concerns;
 - Rapid response to infrastructure threats, and protocols in place for safety.
- ### What Gaps in Knowledge, Policy, Capacity, or Education Exist?
- Logistics, connections, and agreements with adjacent municipalities, such as the City of Pendleton;
 - Funding and capacity to implement UIR wastewater treatment facility and network;
 - Comprehensive understanding of water use and availability by tribal community, and needs across UIR;
 - Outreach and understanding around existing infrastructure safety, such as around the UIR pipeline and other critical infrastructure;
 - Skill building and services available to assist with septic and sewage issues;
 - FEMA-adjusted expanded floodplain mapping, and how this will change insurance and property availability;
 - Community kitchen feasibility study, development and funding assessment.

Climate Impacts for Built Systems

“Weather related hazards such as severe winter storms, freezing fog, and localized flooding can render roads unusable, stranding residents. A severe winter storm has the potential to disrupt the daily driving routines of the entire Reservation population as well as interrupt services provided regionally by CTUIR’s Kayak Public Transit. (CTUIR Hazard Mitigation Plan, 2016).”

Public transit and communications networks are built systems that are often spread out over a large region and serve different customer demographic groups.

These networks will also experience adverse effects from climate change, and anticipating changes can help early planning to mitigate for future harm to these systems.

5. Potential Disruption of Communication Networks

Telecommunications networks have physical infrastructure that spans large areas of the Pacific Northwest region to bring telephone and internet access to residents of Oregon, Washington and Idaho. These networks have cables and connection hubs that are threatened by climate change impacts and extreme events.

Estimated **236 miles (23%) of fiber optic line in the region is at risk of seawater inundation** (Durairajan et al, 2018) as seen in Figure 3C.5 (page 125).

6. Potential Complications for Public Transit

Public transportation services face additional challenges through exposure to severe weather events. Extreme heat and smoke events create access issues for those who patron and operate public transit, and effects are likely to be seen across public transit service areas.

Impacts are expected to transportation connections to **water, electrical, information communication technology, and petroleum systems** (Markolf et al 2019), as seen in Figure 3C.6 (page 127).

“When we go to these places, we’ll hear the echo of the land in our minds and in our hearts.”
~ Tribal Language Master Speaker teaching

7. Increased Potential for Water– and Air-borne Pathogens

Aging water delivery infrastructure exposed to flood and heat stress can transmit water-borne infectious diseases. Some infectious diseases can become air-borne through water outlets such as toilets and sinks, and can become more virulent as air temperatures increase.

1 cm increase in rainfall results in a 2.6% chance of contracting disease; a 1°C (1.8 °F) increase correspond to a 2.8% increase in likelihood of contracting the disease (Hicks et al, 2007), as seen in Figure 3C.7 (page 128).

8. Opportunities to Mitigate Carbon through Materials Management and Recovery

Waste is a huge contributor to greenhouse gas emissions and represents a large potential to develop adaptation. Much of the municipal solid waste in landfills is biodegradable and could be diverted and recovered, and other materials are recyclable if necessary infrastructure is present.

62% of the materials in landfills are biodegradable, and other non-biodegradable waste materials make up 13% that could be recovered and reused in triage management streams (Abdel-Shafy and Mansour, 2018) as seen in Figure 3C.8 (page 130).

5. Potential Disruption of Communications Networks

“Electrical power and electronic devices have become essential to our society; economics, banking, emergency services and day-to-day living providing lifeline utility systems. Interference with the functioning of these devices, circuits and systems has the potential of severely impacting the citizens of the UIR (CTUIR Hazard Mitigation Plan, 2016).”

Sharing of stories and information is an essential way of creating networks that support climate adaptation and natural disaster response. Fiber optic communication lines and other transmission infrastructure could be adversely affected by increased storms and by sea level rise, affecting communication for both coastal and inland communities.

Figure 3C.5 shows one regional analysis of vulnerable telecommunications infrastructure threatened by sea level rise in Washington State.

- On the map, blue areas demonstrate where a 1-foot sea level rise will cause coastal inundation with corrosive salt water.
- Telecommunications infrastructure like submarine fiber optic cables are shown in red, metro cables are shown in green, and green dots represent termination points that supply end users with telecommunication services.
- Seattle metropolitan area is more vulnerable to internet disruption due to sea level rise than many other coastal cities.
- Projections for the Seattle area estimate **236 miles (23%) of fiber optic line are at risk** of seawater inundation within this century (Durairajan et al, 2018).
- Nationally, an estimated

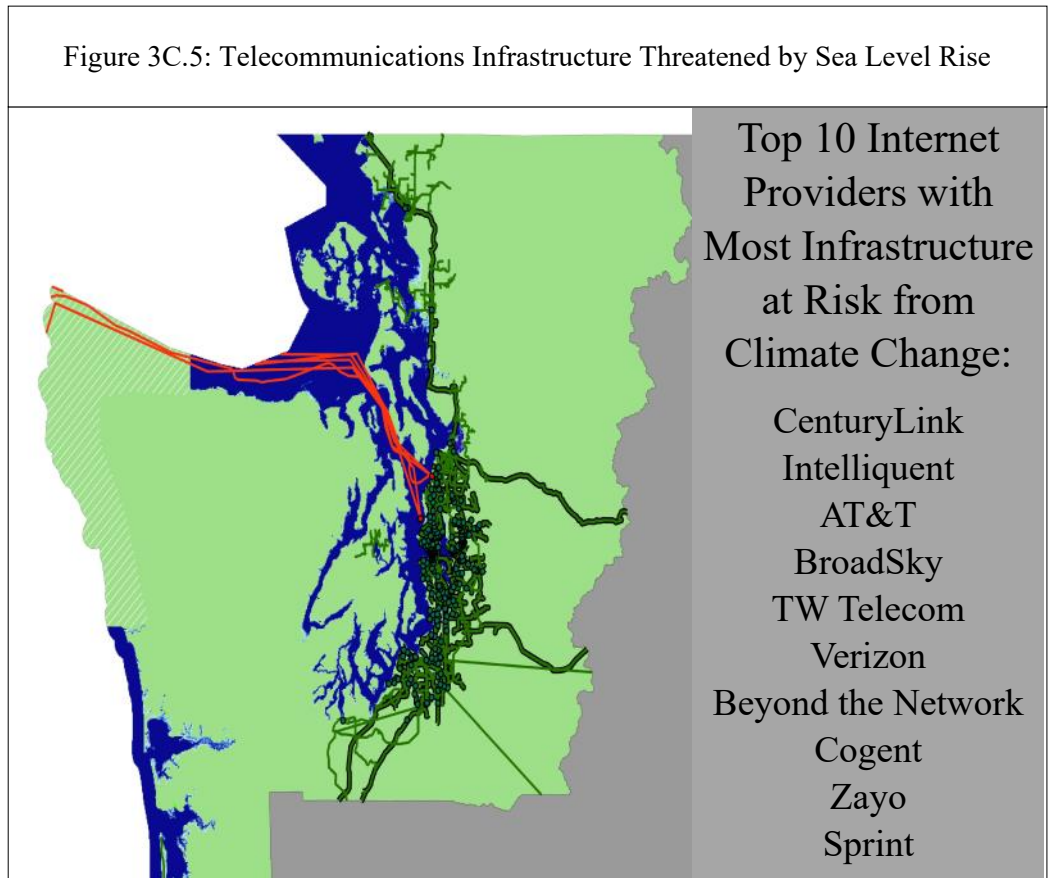
4,067 miles of fiber conduit and over 1,000 termination points will be buried underwater by 2030 (Durairajan et al, 2018).

- The list to the right of the figure ranks ten of the most vulnerable internet providers nationally based on the number of fiber miles and nodes that are threatened.

While this study specifically examines the threat of sea level rise in a coastal city as a proxy estimate, these results are still applicable to climate planning for inland CTUIR. Critical infrastructure are typically located together, and fiber-optic cables, water pipes, and electric transmission lines may all be buried underneath a road or along a road right-of-way.

River flooding, wildfire, and land movement are potential direct threats to buried and above-head communications infrastructure. Indirect risk factors include cyber interconnectedness, which occurs when one infrastructure system depends on data/information from another infrastructure system that is threatened or damaged. One example is traffic signaling (Rinaldi et al., 2001).

Figure 3C.5: Telecommunications Infrastructure Threatened by Sea Level Rise





stories are place names, meanings, and traditional uses, as well as Coyote stories, which get passed on. While technology used to move across the land may have changed, Tribal people’s ties to the landscape have not (Karson Engum and Conner, 2015).”

Transportation systems keep Tribal families and communities connected and able to access cultural places and First Foods harvests. These systems are also a large contributor to greenhouse gas emissions, thus there is an opportunity where reductions would have a large benefit. Mass transportation like the CTUIR Kayak Public Transit System are necessary for reducing emissions of

Broadband Internet cable is installed across much of the Mission and Tutuilla areas of the UIR, and is usually laid concurrently along established roads.

Underground components may be susceptible to flooding and/or land shifting/subsidence from drought or rising water tables. High humidity and extreme temperatures can also increase risk of short-circuiting and component failure (Fu et al., 2016).

Overall, threats to interconnected systems could result in disruptions in traffic management systems, roadside communication systems, real-time traffic monitoring/information systems, real-time public transit tracking systems, GPS and route mapping service, ridesharing services like Uber, and autonomous vehicle systems. (Credit: Durairajan et al, 2018)

Gaps in Knowledge/Data/Policy:

- Inland specific analysis of climate impacts to vulnerable critical communications infrastructure;
- UIR-specific inventory of co-located critical infrastructure currently or potentially threatened by flooding, wildfire, and land movement.

6. Potential Complications for Public Transportation

“As Elders are driven past places they remember on the landscape, stories and memories of the ancestral homelands may be generously shared. Their grandchildren and other fortunate passengers bear witness to these oral accountings. Embedded in these many

transportation systems, but public transit also may face challenges.

Likely, health of transportation system users and operators will be jeopardized by climate and extreme weather events, as heat, flooding, and storm intensity create threats, especially for rural systems.

Hypothetical examples include (Markolf et al 2015):

- Public transit riders exposed to unsafe heat conditions while walking to/from a transit stop, and/or waiting at the stop for their bus/train;
- Extreme heat exposing workers to heat exhaustion is increasingly possible and may warrant the shift of construction hours and/or season;
- Transportation systems performing worse during weather events like heavy snow or rain;
- Transit users and operators exposed to chronic/heavy wildfire smoke during summer operations. Extreme weather can shift commuter choice from active modes (walking, biking etc) to transit and automobiles - potentially putting additional stress on transit systems/roadways.

Transportation systems are necessary to support the function of CTUIR’s region, as First Foods harvest opportunities are rural and remote, and 10% of Umatilla Indian Reservation (UIR) residents lack access to a vehicle (US Census, 2019). Socioeconomically marginalized groups rely on public transit, and

disruptions in services disproportionately impact vulnerable community members (Markolf et al 2019).

Transportation systems also exist within a complex network of additional services infrastructure, and disruptions can have compounding effects.

Figure 3C.6 is a visualization of the way transportation systems are connected to other essential services, and demonstrates network locations that could be potentially disrupted by climate impacts.

- **Water systems** create input for construction, operation, and maintenance of transportation systems. In turn, transportation systems have a co-location of assets (e.g. underground equipment), and access to facilities and infrastructure of water systems.
- **Electrical systems** provide input for operation (e.g. signaling, controls, pumps) and electric vehicle propulsion to transportation systems. In turn, transportation systems provide access to facilities and infrastructure, and the transportation of fuel supply to electrical systems.
- **Information Communication Technology (ICT) Systems** provide traffic management and

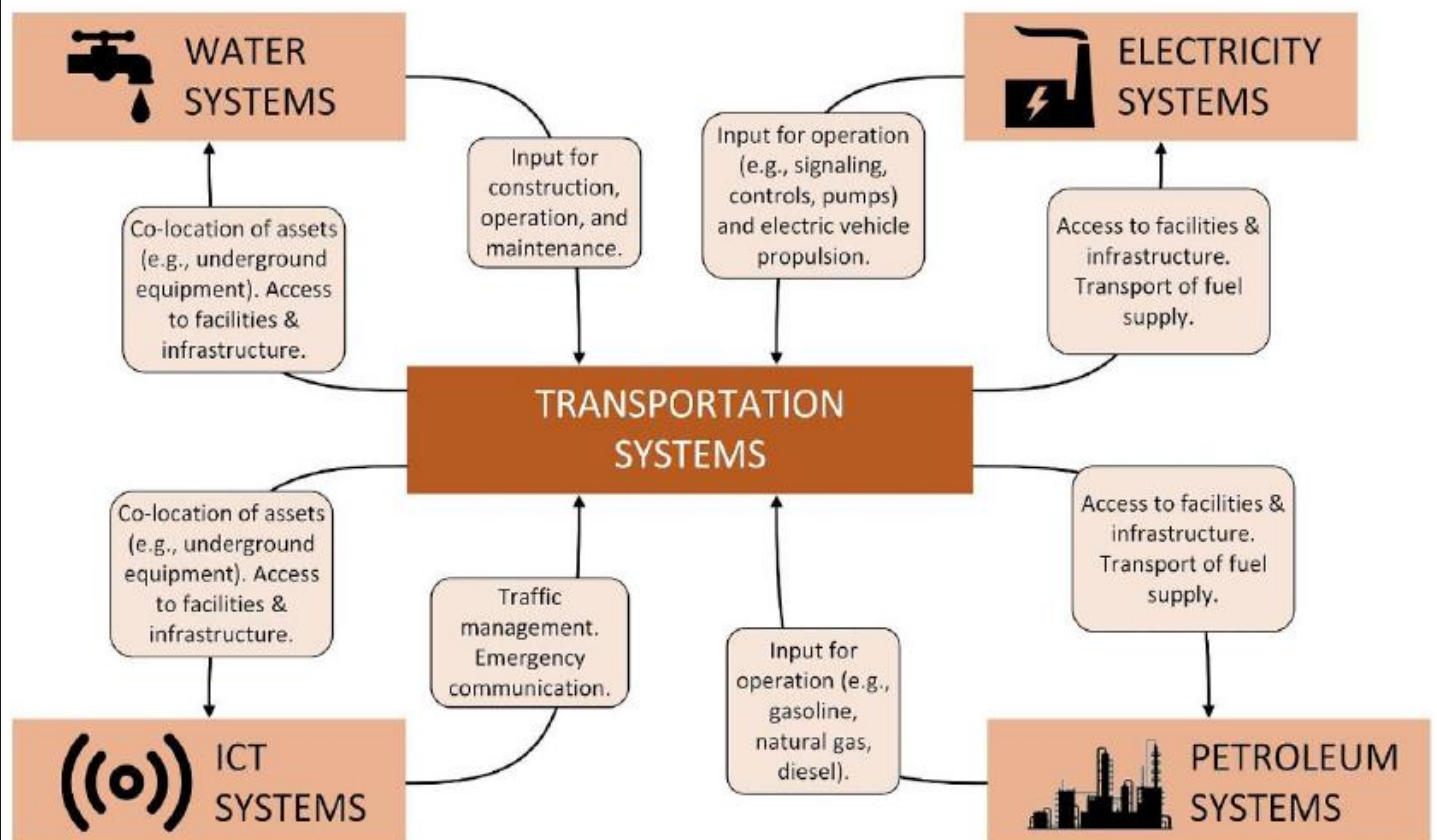
emergency communication to transportation systems. In turn, transport systems provide the co-location of assets (e.g. underground equipment), and access to facilities and infrastructure to ICT systems.

- **Petroleum systems** provide input for operation (e.g. gasoline, natural gas, diesel) to transportation systems. In turn, transportation systems provide access to facilities and transportation of fuel supply to petroleum systems.

Detaching the connection between transportation and petroleum systems is where much of climate adaptation work can be accomplished. In a food systems assessment (FSA) conducted by Yellowhawk Tribal Health Center in 2020, 96% of survey respondents identified private vehicle as their primary way of accessing grocery options, while only 3.8% of participants used Kayak Public Transit services, and 11% commuted with friends or family (CTUIR FSA, 2020).

Expanding reliable public transit is necessary to build climate resilience, and systems development

Figure 3C.6: Transportation Systems are Interconnected with Other Essential Service Networks



which includes climate adaptations reduces future burdens. These interconnections and potential disruptions are essential to consider to support and expand public transportation into an uncertain future.

(Credit: Markolf et al, 2019)

Gaps in Knowledge/Data/Policy:

- Updated Kayak Transportation Plan, anticipated in 2022, and changing rider needs;
- Impact of coordinated ride share programs, as well as private application companies on transportation needs and carbon reduction opportunities.

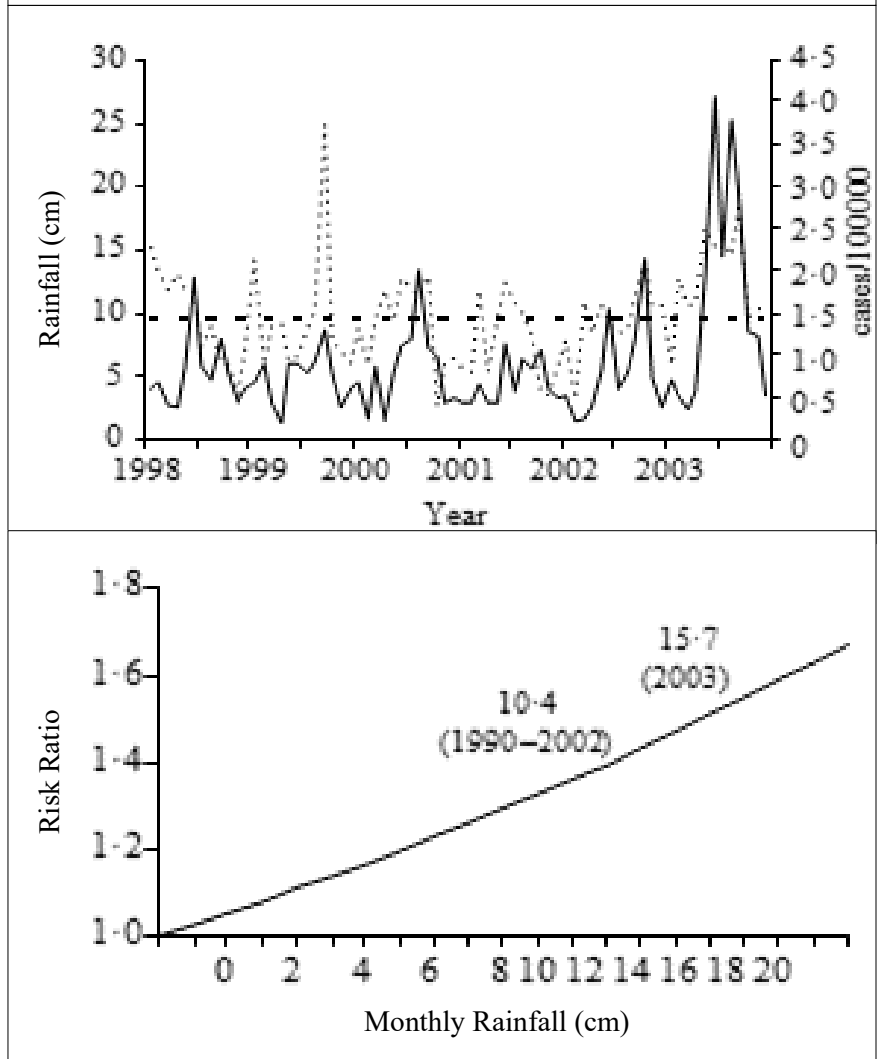
7. Increased Potential for Water- and Air-borne Pathogens

“Restricted access and degradation of the Umatilla River Basin can reduce the availability (and potentially nutritional quality) of First Foods, impacting the health of the Tribal community... Degradation results in reduced water quality, requiring additional purification of river water for drinking to remove pathogens, nutrients, and contaminants (Umatilla River Vision, 2011)”

Water contamination from different sources will become an increasingly frequent concern due to climate impacts. Water and warm temperatures are an excellent source of infectious organisms like bacteria, mold, fungi, and viruses. There are a number of different pathways for climate shifts to increase potential to cause water contamination, including (but not limited to):

- Increasing precipitation over heavily agricultural lands increase potential for nitrate pollution to leach into groundwater;
- Heavy flooding events overtop residential well caps, and flood buried septic tanks that can leach sewage into aquifers;
- Harmful algal blooms in drought and heat conditions create toxicity issues for still or slow-moving water bodies;
- Stress on water delivery infrastructure increasing due to flooding and drought cycles that shift land

Figure 3C.7: Precipitation and Incidences of Legionnaires Disease Over Time (Top) and in Relation to Rainfall (Bottom)



- and threaten stability of buried lines;
- Fungal filaments found in disturbed soils can become airborne and create respiratory infections that could require treatment and/or hospitalization.

Figure 3C.7 illustrates just one of these contamination pathways, showing how heavy precipitation events and flooding can increase incidents of bacteria *Legionella spp*, which can cause Legionnaires’ disease in humans.

- In the top panel chart, precipitation is presented as a checked line, while compared to a plot of incidences of Legionnaires’ disease as the solid line, in New England in the early 2000’s. As observed, sharp increases in the disease follow heavy precipitation events;
- In the bottom panel graph is the direct correlation between the amount of monthly rainfall and the

risk of contracting Legionnaires’ disease during this period in time.

- As precipitation goes up, there is a linear increase in prevalence of this water-borne illness, estimated a **1 centimeter increase in rainfall resulted in a 2.6% chance of contracting the disease.**
- Over this one year period, a **5.3 cm increase in rainfall resulted in a 14.6% increase in the chances of contracting this illness.**
- The same study also linked the increasing risk of Legionella with increasing temperatures, identifying a **1°C (1.8°F) increase correspond to a 2.8% increase in likelihood of contracting the disease** (Hicks et al, 2007).

Legionnaires Disease is carried by water traveling through pipes contaminated with the bacteria, and becomes aerosolized at some termination source (ex: toilet flushing, high pressure sink faucet etc). This bacteria, when inhaled, can result in pneumonia-like symptoms of a bacterial lung infection. While Legionella is just one example, water transfer infrastructure faces a number of these potential incidents of water-borne illness from contaminated points in a vast delivery network.

Valley Fever, a respiratory infection caused by the fungus *Coccidioidomycosis*, is another concern as an air-borne pathogen set to expand in a climate shifted future. Valley Fever is contracted by breathing in fungal filaments attached to air-borne dust particles from infected agricultural soils, kicked up during activities like tillage (Gorris et al 2019). While Valley Fever is currently endemic to the U.S. Southwest, warm wet season followed by a duration of extreme heat create conditions that benefit the growth and spread of this fungus further northward in the future.

Additional information on Valley Fever can be found in Chapter 3D.4 on page 147.

(Credit: Hicks et al. 2007)

Gaps in Knowledge/Data/Policy:

- Contamination sources of highest concern: assessment and mapping needed to identify areas of current and emerging regional contamination issues;
- Coordination and reporting of health issues related to biological contamination among overlapping health and public service entities.
- How airborne pathogens that impact communities, including those like *Coccidioidomycosis*, or “Valley Fever” may be affected by conditions and land use policy.

8. Opportunities to Mitigate Carbon Release through Materials Management and Recovery

“An important success the CTUIR has had in establishing self-sufficiency has been the contracting of a number of important economic, environmental, social and community programs that were once provided by the BIA or by other local, state and Federal agencies (CTUIR Comprehensive Plan, 2010).” One example of this has been in the realm of waste management.



Seasonal flooding can create conditions for pathogens to thrive in piped infrastructure, and is made worse when followed by periods of drought and prolonged heat.

Landfills are a large contributor to carbon emissions, but expanding capacity to address opportunities in waste management present an efficient approach to mitigate carbon release and improve services to Tribal communities. CTUIR’s Tribal Environmental Recovery Facility (TERF) is a great example of Tribal sovereignty strengthening approaches to climate adaptation by improving Tribal self-sufficiency and providing community services.

Biological materials like food scraps, lawn clippings, and other once-living debris can end up in landfills, where it breaks down without oxygen to create methane. Methane is a very strong greenhouse gas that has 24-34 times the heat-trapping power of carbon dioxide in the short term,

which grows to 84-86 times that of carbon dioxide over a 20-year period (UNECE 2022). Landfills account for roughly 17% of U.S. methane emissions annually (US EPA, 2013).

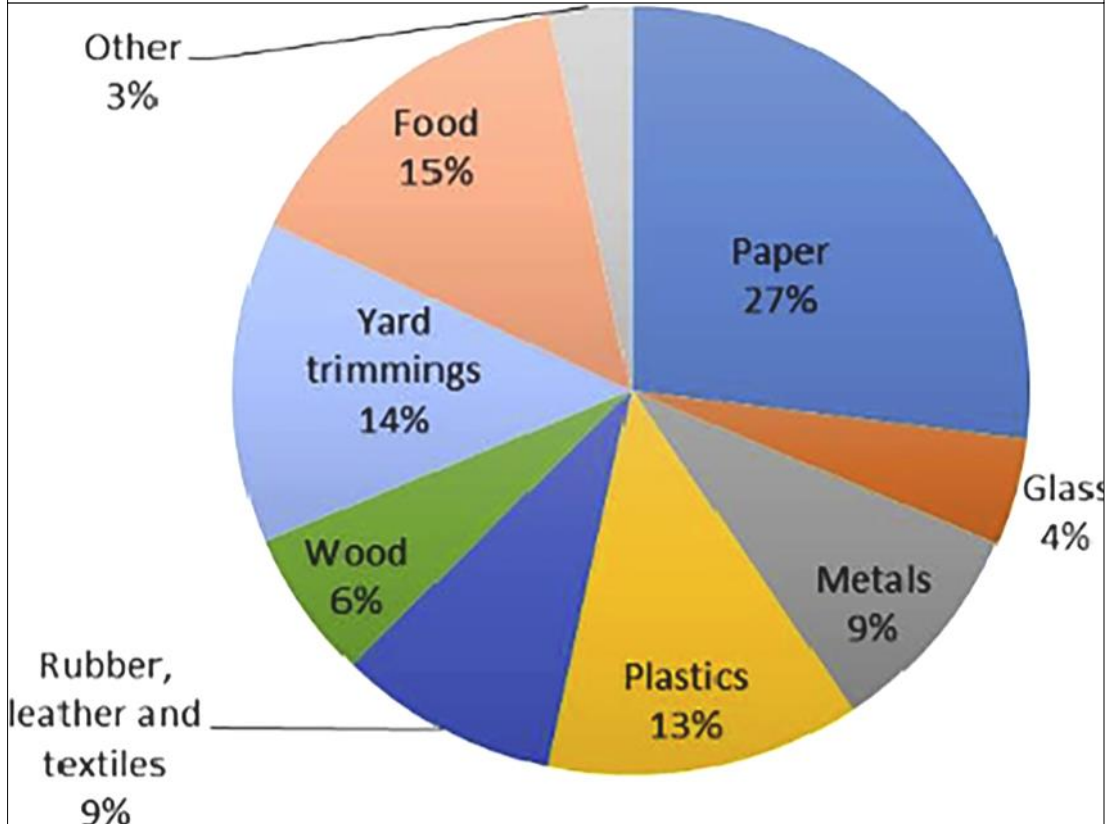
Figure 3C.8 is a pie chart overview of different materials that entered landfills in the United States (2013).

- Total amount entering landfills was 254 million tons of waste;
- **Reclaimable biodegradable waste including paper, food, yard trimmings, and wood, accounts for 62% of the materials** that end up in landfills (Abdel-Shafy and Mansour, 2018).
- **Other non-biodegradable waste materials include glass and metals make up 13% that could be recovered** and reused in triage management streams (Abdel-Shafy and Mansour, 2018).

Using proactive materials management to divert especially biological waste from landfills presents a tremendous opportunity to reduce carbon release regionally. Activities like food waste capture and composting could also keep important nutrients and resources in communities in a way that is useful, and has the potential to create employment and Tribal enterprise opportunities. Some places within the Tribe’s Ceded lands and on the UIR do not have adequate access to materials disposal (barriers may include funds and time available) and will often resort to open burning of garbage, which creates air pollution, or burying garbage unpermitted.

Research has shown that decreasing distance to the recycling bins for households increases compliance with collecting and sorting solid waste. Strategies for local governments can take must

Figure 3C.8: Analysis of Waste Components within the United States



encourage markets for recycled materials, increase professional capacity in the waste management operations, and provide financial support for implementing recycling projects (Abdel-Shafy and Mansour, 2018). CTUIR community members have expressed interest in curbside recycling options (CTUIR CAP W6, 2021), as current operations require recyclers to visit the TERF station to dispose of materials, which can be a barrier. Much of this material can be recovered with composting and bio fuels processing, but facilities need to plan to recover these materials, and investments in technology and infrastructure must be present to utilize these kinds of opportunities.

(Credit: Abdel-Shafy, M.S.M. Mansour, 2018)

Gaps in Knowledge/Data/Policy:

- Detailed estimates of types of waste collected and processed by TERF on the UIR;
- Additional capacity and funding needs to implement identified waste recovery projects;
- Assessment of CTUIR’s volume of food, yard, and paper waste that could be recovered.

Adaptation Goals for Built Systems

D. Resident and Community Preparedness, Response, and Services

“The land hears our songs, warms to our footsteps, responds to our prayerful manners, and is alive with its own stories. Each generation inherits responsibility for the land and all that live on it, and it is our duty to keep the names and the stories alive (Morning Owl et al 2015).”

Communications and transportation infrastructure are typically interconnected across large distances, and will experience direct and indirect impacts from climatic changes. These services are often necessary for emergency response as well as daily operations, and planning ahead to anticipate impacts could save money and lives.

i. Improve Knowledge of and Response to Water-borne Illness

Flooding and drought will cause increased potential for water contamination, especially within watersheds and infrastructure where water pools and sits still.

Short Term:

- **Assess and inventory potential water contamination sources**, including from residential septic leaching, agricultural chemical run off, and from biological sources like bacteria; mapping of these sources could inform future mitigation actions to prevent serious illness.
- **Support community skills and knowledge around water-borne illness**, common signs and symptoms of diseases and disorders of concern, diagnostic procedures and requirements, and possible treatment/mitigation options. Improving community understanding of response increases

capacity to address emergency issues in a standardized but decentralized manner.

Long Term:

- **Expand water contamination and illness testing to be most accessible**, including sampling and tracking protocol for biological contaminants, information about necessary testing (blood, water, stool sampling etc) for each contaminant of concern, locations and contact information for testing sites, and connect with community on actions that can be taken to improve reporting.



Umatilla Indian Reservation (UIR) residents and flood responders chat casually as floodwaters pour across the adjacent pasture. Note the inundated and stranded white pickup truck behind them in the photo.

- **Continue engaging with surface and groundwater contamination tracking and coordination efforts**, such as the Lower Umatilla Basin Groundwater Management Area (LUBGWMA) and in other basins like the Walla Walla and Columbia Rivers.

ii. Improve Knowledge of and Response to Air-borne Illness

Many sources of air pollution are likely to increase due to the climate crisis. Many of these sources of air pollution either cause illness themselves (such as ozone’s impact on asthma), or are associated with biological contagions that cause illness, like fungi and bacteria that can infect respiratory tract or other systems in the body.

Short Term:

- **Coordinate with DNR’s Air Quality program to inventory existing air quality contamination sources**, including from industrial, agricultural, residential, and natural sources, and begin to assess how these are likely to change with climate.

- **Identify land and resource management practices that increase the potential for contamination** (such as aggressive soil tillage, riparian-adjacent livestock grazing, and excess nitrogen fertilizer applications), and recommend mitigation strategies.
- **Support community skills and knowledge around air-borne illness and contamination**, common signs and symptoms of diseases of concern, diagnostic procedures and requirements, and possible treatment/mitigation options.

Long Term:

- **Improve or develop diagnostic testing for emerging diseases of concern** due to a changing climate, such as the potential for Valley Fever and Radon poisoning, and for other infectious diseases that are problematic in contaminated or poorly ventilated spaces. This could involve working with external partners to secure capacity, or investing in new testing equipment and staffing with the Yellowhawk Tribal Health Center Laboratory. See Ch 3D pages 156-160 for additional details.
- **Encourage community agency around respiratory safety and decision-making**, which

includes awareness of possible biological contamination and the potential to become air-borne in given situations. Providing baseline education and equipment that is required for informed decision making can expand community capacity to act in inclement situations, while still preserving cultural connection and autonomy. See Ch 3B pages 97-98 for additional detail.

E. Strengthen Opportunities to Divert Materials from Landfills

“This is our mother this country, as if we drew our living from her (*Ictixec*, 1855 Treaty Council).”

Developing and expanding alternative pathways for waste that reduce materials deposited in landfills can improve not only adaptation and resilience, but quality of life.

i. Expand Biological Materials Recapture

Organic material is well-suited to be returned to natural processes through composting and other methods of disposal. Expanding this biological materials disposal is likely to require expansions in capacity, infrastructure, and education.

Short Term:

- **Develop and support biological materials composting as a part of TERF services**, which includes securing land, equipment, and staffing capacity requirements. This is likely to include an increase of at least 1 position dedicated to building this capacity, as well as some infrastructure and equipment investments.
- **Repair wood chipping equipment donated from DNR to TERF** to provide woody debris rendering services to community, which can be used for woody resource for gardens, trails, compost operations, and other projects. This chipper is currently non-operational but only needs to have certain parts replaced to be operation, and could provide wood chipping capacity to the community to divert wood waste from landfills and slash piles.



Road sign for the CTUIR Tribal Environmental Recovery Facility (TERF) that serves residents on the UIR.

Long Term:

- **Provide capital investment to TERF to expand facilities and services**, as well as support additional staffing capacity. Large funds investment is likely to be required to expand TERF's capacity to collect, process, and distribute compostable materials. At minimum will likely require concrete slabbing, equipment purchase, and other potential infrastructure investments. See Ch 3F pages 228-229 for additional detail.
- **Conduct a waste management assessment for CTUIR operations** to identify where/what kind of waste is generated, potential opportunities to divert select materials from landfills, and barriers to implementing strategies. Such an assessment could provide a complete mapping of common materials use, and could be paired with a goods and services, and biological materials recapture inventory. See Ch 3F pages 228-229 for additional detail.

ii. Expand Knowledge of and Access to Materials Recycling

Misinformation and changing capacity of global recycling systems create confusion around what materials are and aren't recyclable, and many lack easy access to points of materials recapture.

Short Term:

- **Facilitate education campaigns to build community skills for addressing recycling issues**, such as Portland's Master Recycler Programs (www.masterrecycler.org), and the ReBuilding Center classes (www.rebuildingcenter.org) can build community knowledge and reduce contamination in recycling streams. Such programs could be organized alongside existing outreach efforts and with partners that can facilitate additional education initiatives.
- **Develop capacity to provide curbside/clustered and expanded access to recycling** for the CTUIR community. Travel to waste disposal centers and hours of operation are likely large barriers for the Tribal community to fully utilize recycling options offered through TERF, and many community members have expressed the need for easier access to expand their ability to recycle.

Long Term:

- **Conduct a community inventory of materials recovery opportunities and barriers**, which would gauge knowledge and engagement of existing services, gaps that exist in recovery opportunities, and identify barriers to accessing garbage and recycling utilization. See Ch 3F pages 228-229 for additional detail.
- **Develop capacity to provide curbside/clustered and expanded access to recycling** for the CTUIR community. Travel to waste disposal centers and hours of operation are likely large barriers for the Tribal community to fully utilize recycling options offered through TERF, and many community members have expressed the need for easier access to expand their ability to recycle.



TERF operates on the UIR and serves residents of the reservation. This waste management facility offers waste disposal and recycling services to the CTUIR community, and is operated by the Dept. of Economic and Community Development (DECD). Expanded services identified by the CTUIR community include curbside recycling and composting.

Measuring Success and Gaps in Built Systems Adaptation



Long term planning for the CTUIR Mission community has been conducted with input from the community's visions for the area, with one such engagement event hosted in the Board of Trustees Chambers in the NGC as pictured.

How Do We Measure the Success of These Adaptations?

- **CTUIR Transportation Systems Plan** (updated 2022) measures and benchmarks.
- **Comprehensive Plan Objective 5.12.1:** Assure that community facilities are designed and sized to meet the long term needs of the CTUIR (see Comp Plan page 112 for benchmarks);
- **Comprehensive Plan Objective 5.13.4:** Develop transportation systems necessary for all forms of transportation in order to provide for economic development, employment, senior and disabled, health care, education, shopping, visiting family and friends, fitness and legal access (see Comp Plan page 117 for benchmarks);
- **Comprehensive Plan Objective 5.13.7:** Develop, maintain, and improve transportation systems to minimize or reverse environmental degradation from transportation systems (see Comp Plan page 117 for benchmarks);
- **Comprehensive Plan Objective 5.13.9:** Design, build, and maintain transportation systems with the future in mind (see Comp Plan page 117 for benchmarks);
- **Comprehensive Plan Objective 5.13.2:** Ensure that Tribal citizens have access to traditional, gathering, and other traditional activities (see Comp Plan page 117 for benchmarks).
- **CTUIR Hazard Mitigation Plan (2021) Section 5: Mitigation Strategy Implementation and Integration** (page 214-225).
 - Tonnage of materials diverted from landfill annually; adequacy of waste management services over customer base
 - Contamination levels of recycled materials to TERF as a measure of awareness.
 - Communications reliability, both in time and reach to community members.
 - Biological and chemical contamination monitoring and reporting.
 - Level of service and quality of Kayak Public Transit, and ability to service the region.
 - Community engagement around long term planning.

What Gaps in Knowledge, Policy, Capacity, or Education Exist?

- Population changes anticipated as a result of climate migration, or pandemic;
- Global and regional changes in recycling and waste management potential;
- Composting operations needs include available land, additional staffing, and equipment;
- Current locations of contamination sources and severity of potential for future issues;
- Mapping of reoccurring problem areas to anticipate changing community needs;
- Anticipated impacts to Kayak riders and operators.

Infrastructure and Built Systems Summary

Physical Infrastructure Adaptation

Built Systems Adaptation

- A. Identify Ongoing and Emerging Hazards and Opportunities on the UIR and CTUIR Ceded Lands.**
- B. Anticipate Changing Community and Climate Demand on Facilities for Investment Planning**
- C. Develop Sustainable Housing and Walkable Communities**

Extreme weather events and long term chronic stress from multiple sources will challenge effectiveness and longevity of facilities and systems. Infrastructure that supports Tribal Rights, ecosystem restoration, and First Foods access should be prioritized.

Measures of Success:

- Land Development Codes maintained and updated by TPO to provide guidance.
- CTUIR Comprehensive Plan Objectives 5.5.1, 5.5.2, 5.9.7, 5.13.5, 5.13.6, and 5.13.10 and their associated benchmarks.
- CTUIR Hazard Mitigation Plan (2021) Section 3 and 4
- Appropriate and energy efficient housing availability.
- Multi-use development zoning for carbon-free commutable neighborhoods

- D. Resident and Community Preparedness, Response, and Services**

- E. Strengthen Opportunities to Divert Materials from Landfills**

Systems that support transportation and communication are vulnerable to short and long term climate impacts that have transit and public safety implications.

Measures of Success:

- CTUIR Special Transportation Plan and update provides specific guidance and benchmarks;
- CTUIR Comprehensive Plan Objectives 5.12.1, 5.13.4, 5.13.7, 5.13.9, and 5.13.2 and their associated benchmarks.
- CTUIR Hazard Mitigation Plan (2021) Section 5
- Improve utilization of TERF materials recapture services, including waste disposal and recycling.
- Implement TERF composting capacity.
- Maintain and expand Kayak Public Transit services.
- Invest in broadband and community-scale communication networks.



Chapter 3C References and Credits

Literature References

Abdel-Shafy, Hussein I.; Mona S.M. Mansour. 2018. “Solid waste issue: Sources, composition, disposal, recycling, and valorization.” *Egyptian Journal of Petroleum* 27 (2018) 1275–1290

Barn, Prabjit; Larson, Timothy; Noullett, Melanie; Kennedy, Susan; Copes, Ray; and Brauer, Michael. 2008. “Infiltration of forest fire and residential wood smoke: an evaluation of air cleaner effectiveness.” *Journal of Exposure Science and Environmental Epidemiology* (2008) 18, 503–511.

Clifton, Caty F.; Day, Kate T.; Luce, Charles H.; Grant, Gordon E.; Safeeqe, Mohammad; Halofskyf, Jessica E.; Staaba, Brian P. 2018. Effects of climate change on hydrology and water resources in the Blue Mountains, Oregon, USA. U.S. Forest Service, Pacific Northwest Region, Portland, OR, USA. *Climate Services* 10, pgs 9-19.

Confederated Tribes of the Umatilla Indian Reservation (CTUIR) Hazard Mitigation Plan. 2016. <https://ctuir.org/media/xydmr1pt/ctuir-hazard-mitigation-plan-part-a.pdf>

Caudill, L. 2020. Confederated Tribes of the Umatilla Indian Reservation (CTUIR) First Foods and Food Systems Assessment (2020)

Durairan R, Barford C., and Barford, P. 2018. “Lights Out: Climate Change Risk to Internet Infrastructure.” ANRW ‘18, July 16, 2018. Association for Computing Machinery. ACM ISBN 978-1-4503-5585-8/18/07 <https://doi.org/10.1145/3232755.3232775>

Hicks L. A.; Rose Jr. C. E; Fields B. S.; Drees, M. L.; Engel, J. P.; Jenkins, P. R.; Rouse, B. S.; Blythe, D.; Khalifah1, A. P.; Feikin, D. R.; and Whitney, C. G. 2007. “Increased rainfall is associated with increased risk for legionellosis.” *Epidemiol. Infect.*, 135, 811–817. Cambridge University

Press. doi:10.1017/S0950268806007552

Markolf, Samuel A.; Hoehnea, Christopher; Mikhail, Andrew Fraser; Chester, V.; Underwood, B. Shane. 2019. “Transportation resilience to climate change and extreme weather events –Beyond risk and robustness.” *Transport Policy* 74 (2019) 174-186. <https://doi.org/10.1016/j.tranpol.2018.11.003>

Rinaldi, S. M., Peerenboom, J. P., & Kelly, T. K. 2001. “Identifying, understanding, and analyzing critical infrastructure interdependencies.” *IEEE control systems magazine*, 21 (6), 11-25.

Tohver, I.; and Hamlet, A.F. 2010. “Impacts of 21st Century climate change on hydrologic extremes in the Pacific Northwest region of North America.” Chapter 7 in Final Report for the Columbia Basin Climate Change Scenarios Project, Climate Impacts Group, Center for Science in the Earth System, Joint Institute for the Study of the Atmosphere and Ocean, University of Washington, Seattle.

Wisdom, M. USFS. “Possible Effects of Climate Change and Drought on Elk: Potential Implications for Ungulates in the Interior West.” Presentation to the Wildlife Society, Sept 27 2017; Albuquerque, NM.

Photo Credits

- Part C Cover Photo, “DNR Fisheries staff move juvenile salmon to hatchery gate,” CTUIR DNR Fisheries
- Background Photo, “Historical marker for Feb 2020 flooding,” Althea Huesties-Wolf, 2020
- Background Photo, “Young Chokecherries at CTUIR Native Plant Nursery,” DNR FFPP 2019
- Inset photo, “Thornhollow Bridge damage from Feb 2020 flood event,” CTUIR DNR 2020



- Inset Photo, “Wildlife Presence Warning Sign at HNR,” CTUIR FFPP 2022
- Inset Photo, “Reith Road and bridge flooded by Umatilla River,” CTUIR DNR CRPP Jennifer Karson-Engum 2020
- Panel Photo, “Red sun visible mid-day over NGC parking lot through thick wildfire smoke,” CTUIR DNR FFPP 2020
- Inset Photo, “CTUIR Housing unit inundated with groundwater around foundation,” CTUIR Housing
- Panel Photo, “Dark clouds over the Umatilla River basin,” CTUIR DNR 2020
- Inset Photo, “Greenspace with cattails and tuli reeds outside Yellowhawk,” CTUIR DNR FFPP 2022
- Panel Photo, “Thick Smoke at Mission Road Intersection,” CTUIR DNR FFPP 2018
- Inset Photo, “Huckleberry Court house on snowy day,” CTUIR Housing
- Inset Photo (top), “Possible proposed use of July Grounds from TPO,” CTUIR Tribal Planning Office 2021
- Inset Photo (bottom), “Artist rendition of Mission Community Master Plan improvements,” CTUIR Tribal Planning Office
- Inset Photo, “Floodwaters pass through Walla Walla city during Feb 2020 flood,” CTUIR DNR 2020
- Background Photo, “Roadway destroyed by Feb 2020 flood,” CTUIR DNR 2020
- Background Photo, “Sunlight Through Tipi at TCI,” CTUIR DNR CRPP
- Inset Photo, “Broadband internet cable being laid on UIR,” CTUIR DECD
- Inset Photo, “Tribal Community and Staff Sandbag Around Buildings in Flood,” CTUIR DNR WRP 2020
- Inset Photo, “Boys shooting the breeze in floodwaters,” CTUIR DNR 2020
- Inset Photo, “CTUIR TERF Sign,” CTUIR DECD
- Inset Photo, “CTUIR Tribal Environmental Recovery Facility,” CTUIR DECD
- Inset Photo, “Community listening session for the Mission community,” CTUIR Tribal Planning Office
- Summary Inset Photo, “Juvenile salmon are transferred at the DNR rearing ponds,” CTUIR DNR
- Panel photo, “Bachelor Button Flowers Over Pendleton,” CTUIR DNR FFPP 2018
- Inset photo, “Flooded home and stranded vehicle along the Umatilla River,” CTUIR DNR 2020.



Many homes on the UIR exist in the Umatilla River floodplain, and are at risk of repeated inundation from every future flood event. Flooding can impact evacuation strategies. Relocating homes out of the floodplain would improve public safety.